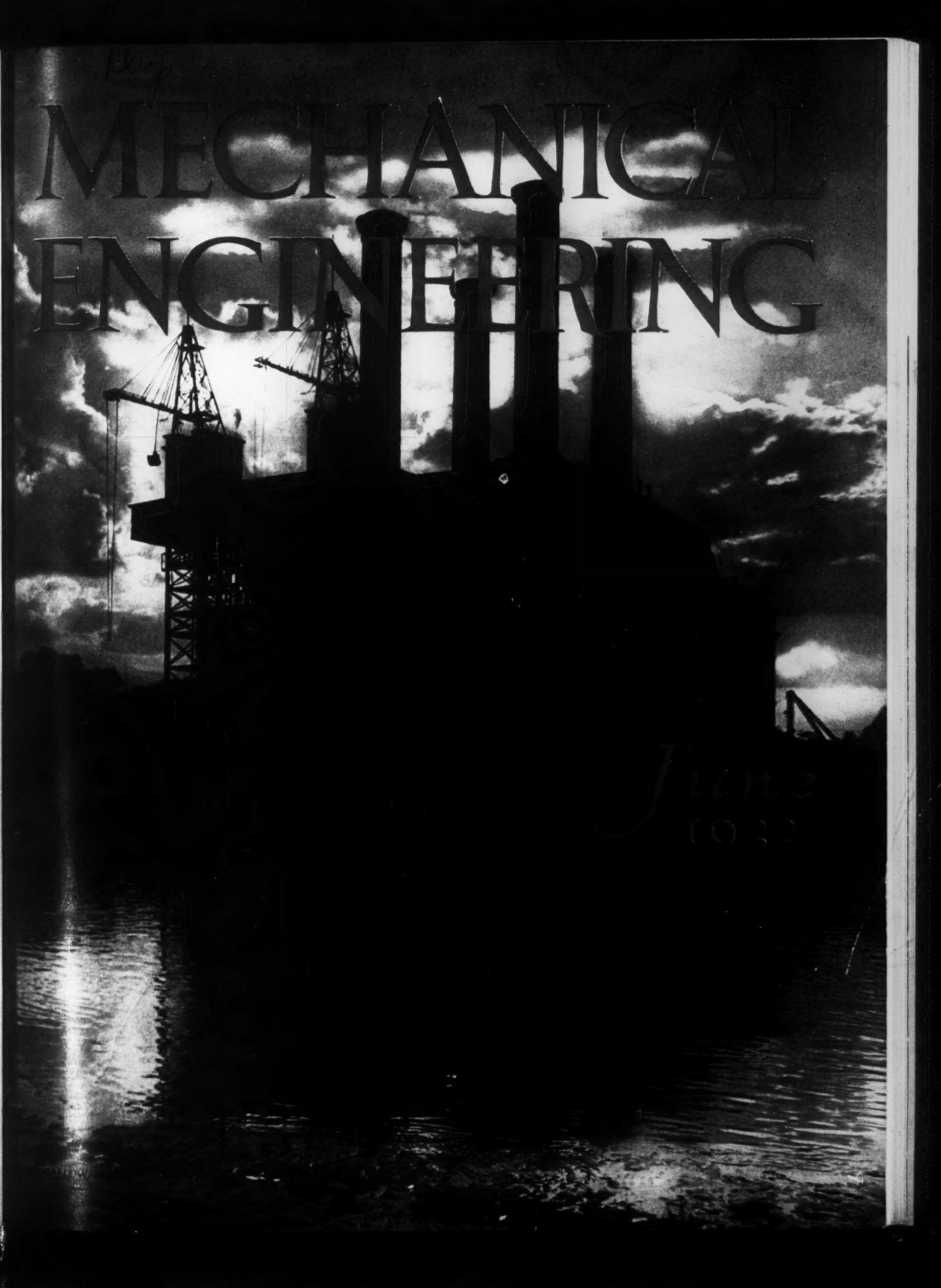
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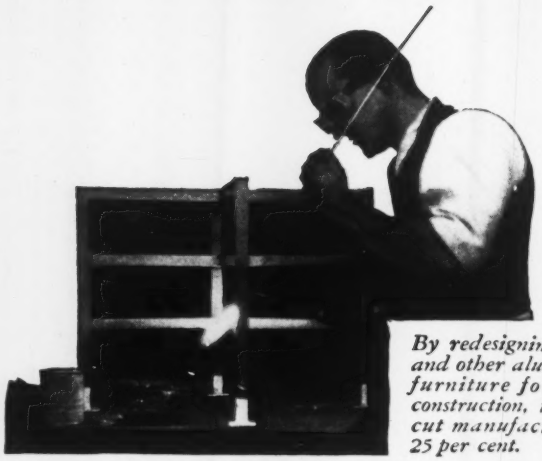

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 54 NUMBER 6

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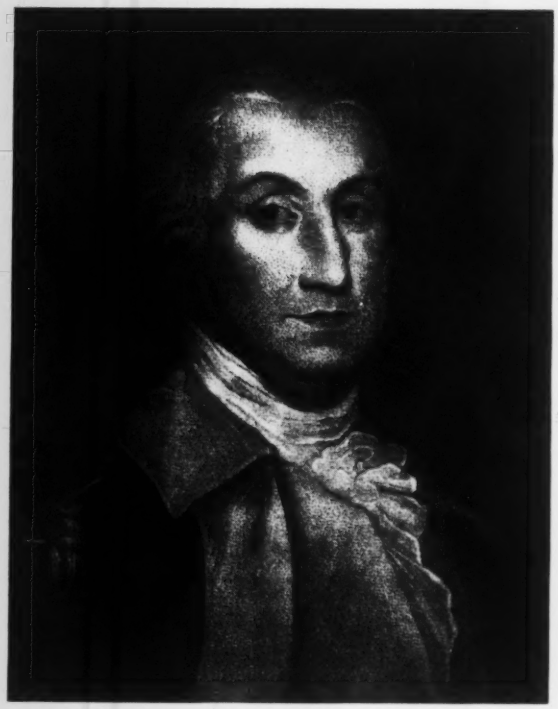
Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of addresses must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1932, by The American Society of Mechanical Engineers.

WHAT IT'S ALL ABOUT

THE majestic structure of the Sherman Creek Power Plant of the United Electric Light and Power Company, located on the Hudson River in upper Manhattan, with its four familiar stacks, is a picturesque sight at any time, and with a winter's sunset for a background it attracted the attention of a photographer who succumbed to its artistic appeal. If justification for using this picture for our cover is needed, we may point to the extensive interest that engineers have in power generation, as indicated by the 8,000 members of the Fuels and Steam Power divisions of The American Society of Mechanical Engineers.

We hope none of our readers will infer from the picture, however, that the sun is setting on the great works of engineers. To give this impression is farthest from our intention.



GEORGE WASHINGTON (1732–1799)
(From an engraving by J. A. O'Neil after a painting by the American artist, Joseph Wright, painted from life in 1783.)

RATHER than resigning to Spenglerian despair with respect to our power-sustained world and predicting its decline, it would be easy for us to call attention to the energy that is made available by this plant in its faithful service to a great city; a source of light for a darkened world, a bearer of the burdens of men and women in home and shop; strong enough to speed their means of travel, accurate and delicate enough to regulate their clocks, versatile and tireless enough to perform thousands of useful but humble tasks. And in the ebb and flow of the tides that sweep past it, first in one direction and then in the other, we are reminded of the eternal return of the seasons, and of the fact that a sunset presages the dawn of another day.

OLDER than man himself, the cyclic rhythms of nature have provided the mystical origins of customs and religions and have governed human life. Hope and despair that found expression in the legends of Persephone, of Adonis, and of Alcestis, and that attained spiritual significance in the festival of Easter, represent the human reactions to these tides of the seasons whose counterparts in history mark the rise and fall of civilizations and in our modern world the fluctuations of economic and social well-being.

TODAY the emphasis has shifted. Industrialization has removed great masses of our peoples from the fundamental experiences of seed time and harvest, has tempered for them the fecund heat of midsummer, and has sheltered them from the icy blight of winter. But for these there are substituted today the economic seasons of the business cycle, whose belated spring now mocks us with uncertain signs. Some economic Caesar or Gregory, able to reform the calendar of business so as to make predictable the lean and the fat years and thus take the first step toward providing against their extreme effects, would perform a useful service to mankind. Just as science came to the aid of Pope Gregory, so the method of science must provide the basis for the economic calendar and the stabilizing influences that may mitigate violent fluctuations of the industrial seasons. Engineers are hopeful enough and bold enough to imagine that with their assistance this may come to pass.

WITH engineers the philosophy of dynamical evolution is an activating force. Less impressed with the discovery of history which conceives of the present as the fruit of the past, they hold with John Dewey in looking upon the present as the cause of future effects, and embrace with enthusiasm the belief that attempts at control are worth while and productive. They have evidence from their experiences with applied sciences that facts form the basis for intelligent action looking toward control, and they are more optimistic than some others in thinking that a control of causes will determine the character of effects.

With characteristic intrepidity, therefore, they have made the study of social and economic conditions presented in this month's MECHANICAL ENGINEERING in the report of a committee of the American Engineering Council. This document, we insist with proper modesty,

is significant of a great change that is going on in the world today, and shows the growing influence of the methods of applied science in human affairs.

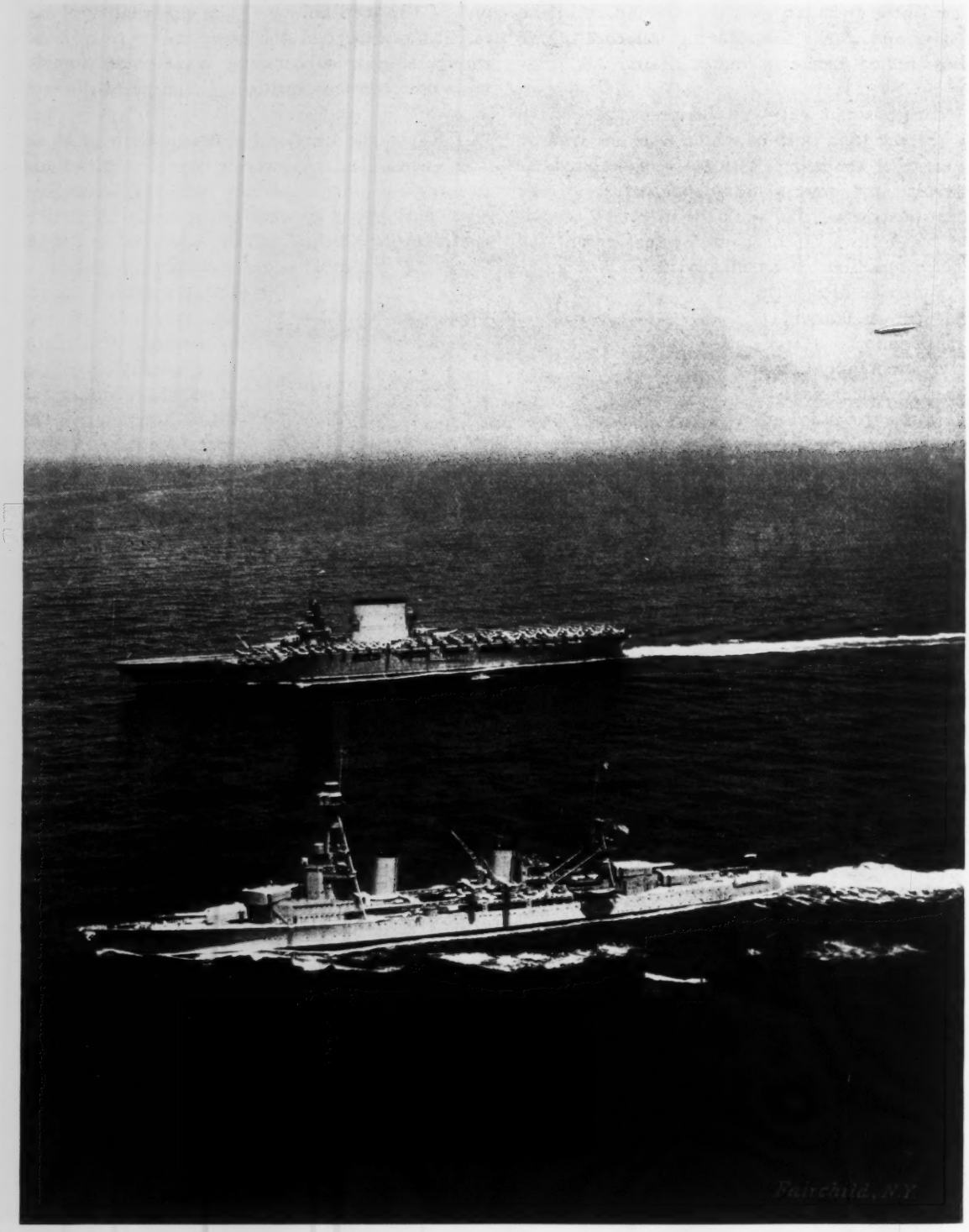
ENGINEERS stand half-way between the artizan and the scientist, both of whom were enslaved by the Greeks. For centuries all three were despised, or misinterpreted, and were seldom appealed to in the government of society. But with the industrial revolution, the possibilities of cheap mechanical power and power-driven machines that multiply man's productive efforts and provide him with an abundance of material goods and comforts, placed engineers in a more important relationship to human affairs. Their activities broadened until they touched the lives of all civilized peoples, upset traditions, gave rapid rise to standards of living, and changed philosophies of government and the significance and importance of international relations.

JOHANN WOLFGANG VON GOETHE (1749–1832)
(Poet and philosopher, whose universal interests embraced science, technology, and the principal industries of his time and nation.)

THE great men of a century and a half ago vaguely sensed the impending changes that science and technology would bring. Washington, the bicentennial of whose birth is being celebrated this year, and Johann Wolfgang von Goethe, the great German poet and philosopher, who died one hundred years ago, witnessed the dawn of this era. In their broad relations to the affairs of state and the culture of their times, they had a lively interest and a small part in applied science. Early experiences as a surveyor, an interest in the development of the canal on the Potomac and the city of Washington, a realization of the importance to the country of the fostering of invention, attested in the Constitution by the provision for a patent system and by the first president's dealings with the steamboat pioneers, Rumsey and Fitch, mentioned by Mr. Richardson in his article on the latter inventor in this month's MECHANICAL ENGINEERING, are evidences of Washington's contacts with technology. Goethe's interest in science, steam power, and electricity, in the industries of the duchy of Weimar, particularly mining, and in the locomotive, a model of which was presented to him although he never saw one, is also well known. The universality of his mind reached out beyond the abstractions of philosophical thoughts in speculation on what these humbler and more practical movements might mean to the world.

YET in the lives and times of both of these men, science and engineering were novelties and side issues. The industrial era was just emerging, and contributions to it were being made by amateurs of the scientific method whose more important interests were the philosophy and conduct of human affairs. Today witnesses the contrasting spectacle of engineers who turn their attention and their talents to the solution of social, economic, and political problems. The conduct of affairs in sociology, in economics, and in politics seems not to have kept pace with advances in technology and science, and to have failed under the strain of rapidly changing conditions. May it not be possible that from the experiences of those who have served industry and science so effectively, may come the means of a more intelligent control of social well-being? A careful reading of the American Engineering Council's report will suggest to engineers that this may be so.

IF ENGINEERS are ever to come into their own, it will be in the immediate future when they can assist others in consolidation of technological progress in the general advance of the material welfare of mankind. Upon the foundation of an abundant and skilfully organized production whose fruits are adequately distributed there may be built a society in which the satisfactions of individuals and their appreciation of values will find expression in the intelligent use of a leisure that is not unemployment, that is accompanied by higher standards of living, and that will permit the flowering of a rich and varied culture. It is our urgent request, therefore, that every reader turn to page 415 and study the report of the American Engineering Council's committee on consumption, production, and distribution. The report contemplates, the authors say, "a purposeful changing of the course of history."



Battleship "Salt Lake City" and Airplane Carrier "Saratoga"

(The airship "Los Angeles" can be seen in the distance at the right)

The AIRPLANE CARRIER[1]

Problems Involved in the Landing and Storing of Naval Airplanes on the Decks of Their Mother Ships

By LIEUT. (JG) H. B. MILLER[2]

THE end of the World War found Great Britain far ahead in the development of the airplane carrier. The United States had devoted her aerial efforts to patrol work which was so essential to the anti-submarine campaign. However, our naval officers had seen the progress made abroad and they returned home eager to have this country participate in a similar development.

At this time Admiral Rodman said, "The mother ship for airplanes is certainly vital to all future navies. I have seen them operate and know they are a necessity. They are in the embryo stage at present, but it is essential that the American Navy should carry on experiments to develop such ships, and that they be made an additional complement of the fighting fleet."

In 1919 Congress authorized the conversion of the collier *Jupiter* into an airplane carrier. However, up to 1921 planes continued to be flown from the turrets of our battleships, and kite balloons were sent aloft from the quarterdecks in order to carry on aerial observations. As is well known, these methods were impractical when placed under the hard demands of the service.

The *Jupiter* was familiar with experiments, for she was the first electric-drive ship in our Navy. Her reconstruction work was completed in 1922, and she lost her identity, for she was renamed the U.S.S. *Langley* in honor of Prof. Samuel Pierpont Langley.

With a flat deck 65 ft wide and 625 ft long, she was a queer-looking craft, indeed. Her resemblance to a "prairie schooner" was so striking that she soon became known throughout the service as "The Covered Wagon."

The arresting gear was of the most simple construction and varied little from that used by Ely ten years before. Athwartship wires were rigged with weights on either end. A suspended hook on the aircraft engaged these wires and brought it to a stop. In order to prevent the aircraft from leaving the deck after once landing, fore-and-aft wires were suspended about 12 in. from the deck. Hanging hooks were installed on the axles of the plane, and if the craft attempted to bounce after settling down, the wires were engaged by the hooks and thus the plane found itself secured firmly to the deck.

To provide for the contingency of a pilot's bringing his plane in for a landing so fast that he could not stop, and also in case his hook failed to engage the athwartship wires, a barrier was erected forward of the arresting gear. It consisted of two heavy steel cables stretched across the deck at a height of 4 ft. If nothing else stopped the plane, these cables brought it up short—to the disadvantage of the aircraft.

With a complement of 40 planes the *Langley* has proved to be a fruitful training ship for the pilots in the operation of the carrier. Her low speed of 14 knots, however, has always hindered her during maneuvers, and for this reason she has never been considered any thing more than an experimental craft. Nevertheless much experience and knowledge has been gained from the naval problems engaged in by this vessel.

When in 1922 the Washington Conference caused the abandonment of our naval building program, two battle cruisers, the *Saratoga* and *Lexington*, were saved from the scrap heap. Since the Navy desired carriers, it was decided to redesign these partially completed hulls for this new service.

Because of their enormous horsepower, 180,000, which gives these ships their high speeds, they are somewhat expensive to operate. This has resulted from the requirements of the original design and must be accepted as the penalty for using ships for other than their intended purpose. Nevertheless these huge vessels have become the backbone of our aerial armada.

As aboard the *Langley*, the landing gear used on the new carriers consisted of fore-and-aft guide wires and athwartship arresting wires.

LANDING SPEEDS

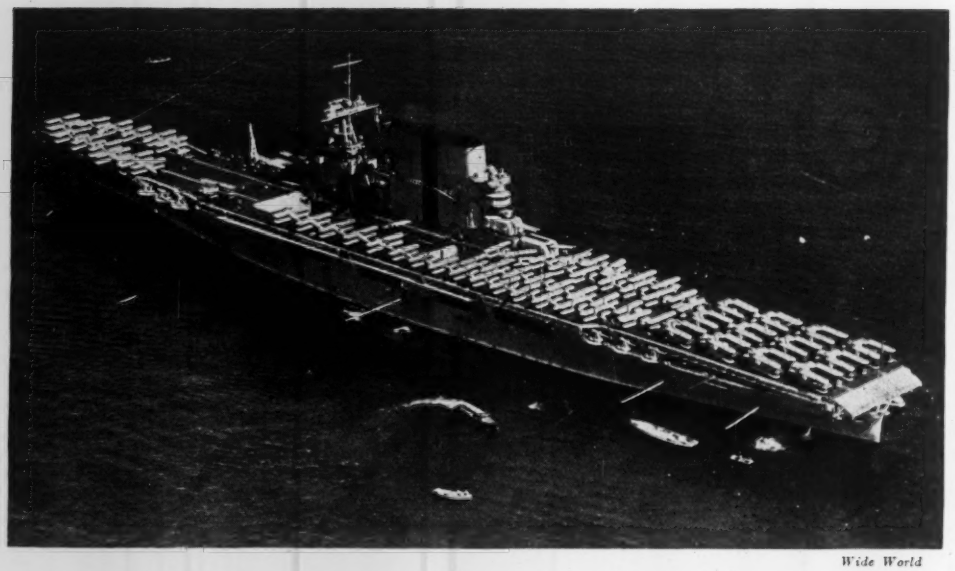
The carrier exerts an important influence upon the landing speed of an airplane. Too fast a speed will mean difficulty in flying the plane aboard the deck of the carrier. Planes that land at close to 65 miles an hour have been successfully taken aboard. Under extremely favorable conditions it is quite possible to land a plane aboard a carrier at much higher rates of speed.

---

[1] The author is indebted to the Editor of the United States Naval Institute Proceedings for permission to use some of the material which was previously published under the title, "Covered Wagons of the Sea," in the Proceedings for November, 1931. Also for some material published in the February, 1932, Proceedings by Mr. Maurice Prendergast under the title, "Wings and Wheels, Wood and Wire." The statements and opinions advanced are those of the author and are not to be construed as reflecting in any way the official views of the Navy Department.

[2] Officer in Charge, Power Plant Division, U. S. Naval Air Station, Pensacola, Fla.

For presentation at the Sixth National Aeronautic Meeting, Buffalo, N. Y., June 6 to 8, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



Wide World

THE AIRPLANE CARRIER U.S.S. "SARATOGA"

However, the worst possible conditions must be taken as the criterion for operation.

It may be that slotted wings, variable camber, or other means will be found to reduce the landing speed of aircraft without materially reducing their maximum speed. If it is found possible to incorporate these ideas in military and naval planes in such a way that they will stand up under the severe operating conditions imposed by the service, they will be well worth while.

When taking planes aboard, the carrier steams ahead into the wind. Obviously the wind over the deck will be the sum of the natural wind and the artificial wind created by the forward speed of the vessel. If the natural wind is stronger than usual, the ship need not steam so fast. If a calm exists, the carrier must steam at a higher rate of speed. Of course, with a maximum speed of 33 knots the large carriers could create a high deck wind even in a calm, or even while steaming down wind for that matter. However, steam vessels are unable to accelerate on the spur of the moment to their maximum speed. Moreover high speeds are uneconomical, and this might conceivably reduce the operating range of the carrier. Therefore the landing speeds of naval aircraft have a natural limitation, and since the speed range remains fairly constant, the maximum speed remains within quite definite limits. It is granted that higher landing speeds than those used at present can still be tolerated, but the carrier does place a very definite limit upon this factor of a plane's performance.

Aside from the necessity for providing the proper deck speed for landing purposes, the carrier has need for high speed for still another reason. It frequently happens that the fleet is steaming down wind when the carrier is required to take its brood of planes aboard. Consequently the latter must turn and steam away from the fleet. If much time elapses the carrier will find herself far removed from the main body, and for a time will be somewhat isolated and unprotected. It is essential, therefore, that she have sufficient speed with which to quickly recover her normal position relative to the fleet.

It is of course essential that maximum control of the carrier plane be had at the stalling speed.

AIR-COOLED VS. WATER-COOLED ENGINES

The subject of air-cooled versus water-cooled engines naturally arises in any discussion of airplane carriers. The favorable power-weight ratio, the lack of plumbing difficulties, and the ease of maintenance have endeared the air-cooled engine to the Navy. The question of visibility for carrier landings arises, however. Undoubtedly the smaller frontal area of the water-cooled engine provides better visibility for the pilot. If the engine is inverted, so much the better. Nevertheless, when flying behind a radial engine the pilot is able to see between the cylinders sufficiently well to enable him to make a proper landing. The demands for visibility will probably preclude the use of the N.A.C.A. and similar cowlings on carrier planes. Cowling of the Townend Ring type, however, is successfully used.

It is to be hoped that the carrier will have sufficient warning to permit its planes to take the air to engage the enemy, nevertheless it is quite possible that this time interval will be very short. Tactical reasons therefore make it highly desirable to use the type of power plant which will warm up the quickest. This is generally conceded to be the air-cooled engine, although proponents of the water-cooled engine will frequently argue the point. As a matter of fact, resistance coils with exterior sources of electricity would probably be helpful in solving this problem, in that the lubricating oil can be kept warm at all times.

The ease of maintenance of the power plant cannot be properly appreciated until one has seen planes secured to the deck of a carrier. They are crowded together in the most impossible positions, and only the accessibility of the radial-type engine makes it at all possible for them to be worked on. Such jobs as changing cylinders would be quite out of the question with liquid-cooled engines.

The reliability of air-cooled radial engines because of their plumbing elimination and their simplicity is well known. The desirability of this quality is better appreciated after one has flown off a carrier in a landplane. Great faith is placed in the power plants of today when

one considers that navy squadrons daily fly landplanes miles over water out of sight of both land and ships without giving the matter a second thought.

FLOTATION GEAR FOR PLANES FORCED DOWN AT SEA

However, to provide for the occasions when a landplane is forced down at sea, it is highly desirable that the plane possess a certain amount of buoyancy. At present flotation gear is installed in each machine. This has proved be quite efficient, and has saved at least one life and much valuable property. In this a bottle of CO_2 is opened when a toggle is pulled by the pilot. At the same time a large rubberized bag is dropped from each side of the fuselage and filled with the gas. These provide excellent buoyancy. The difficulty generally experienced is that the rocking action of the waves eventually chafes the bags, permitting the gas to leak. Formerly trouble was had with the formation of ice in the tubing due to the rapid expansion of the gas, but this has been somewhat overcome by different methods of installation.

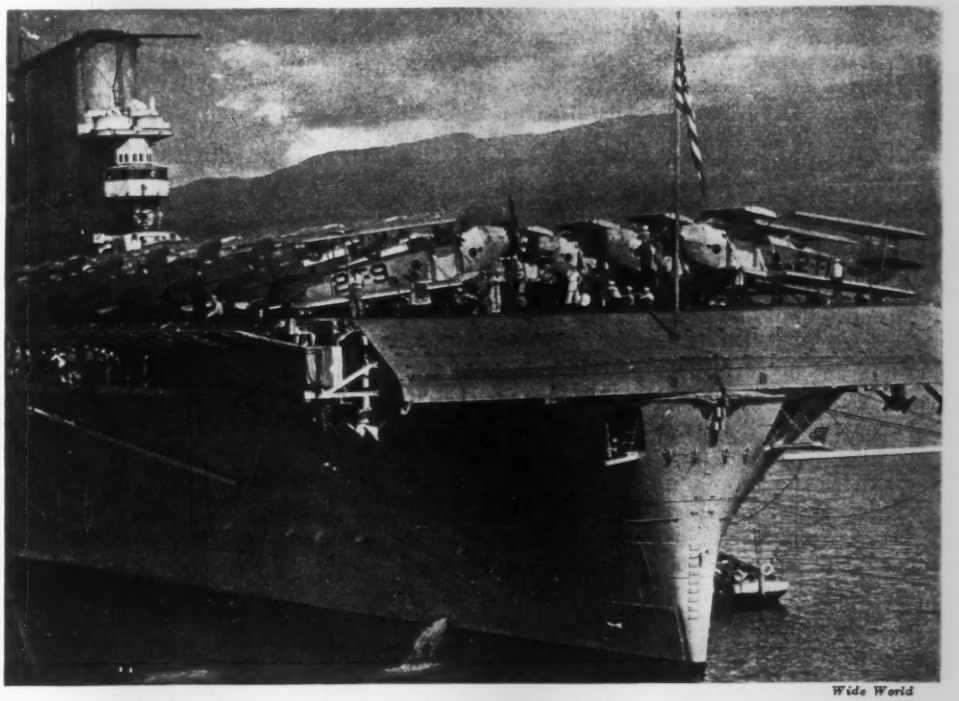
Buoyancy for at least twenty-four hours is desirable. Dump valves in the fuel tanks would contribute a certain amount of assistance in some cases. At the same time these would provide an extra source of leakage and complicate the fuel system. As a matter of fact, most of the cases of planes being forced down have resulted from engines fouling up or getting cold during the slow, idling approach. A forced landing from this low altitude precludes the possibility of the pilot's dumping his fuel. If the plane is forced down because of an exhausted fuel supply, it already has an empty tank to assist in providing buoyancy. Dump valves are not necessarily the solution to this problem. Some ready means should be provided for closing the various outlets of the fuel tank in order to retain every ounce of buoyancy possible. A plane will generally float in such a position that the fuel-tank cap is above water. If the plane is provided with a small siphon pump the pilot can discharge the fuel from the tank after landing in the water, after which he can seal it.

In case long-distance over-water flights are to be made, the planes also carry small air rafts which can be inflated with either an air pump or a small flask of CO_2. During last winter's maneuvers off Panama a Navy pilot, Verne Harshman, was forced down when he became separated from his squadron. After a day spent floating about in his plane he was forced to resort to his life raft, in which he spent another three days before being picked up by a passing steamer. Cases of this kind give naval pilots great faith in their equipment.

It has been proposed to supply landplanes equipped with detachable landing gear to the carriers. The fuselage would be watertight and thus the pilot would be enabled to make a normal seaplane landing in the water. This type of plane has actually been constructed but has never been adopted for use. A pilot need have little fear that his landplane will go over on its back when landing in water, provided, of course, he has made a full-stall landing. Any tendency to land "hot" will naturally throw the tail over the nose when the wheels bury themselves in the water. Then, too, if the landing gear were dropped, the plane would not have the desirable buoyancy offered by the inflated tires. Possibly another solution would be to retain the present type of flotation gear and provide some means for dropping the engine in order to get rid of its weight.

THE QUESTION OF THE AUTOGYRO

At any rate, it is essential that some means be taken to provide a certain degree of safety to the pilots who operate landplanes over water. A high state of morale must be maintained. With this in mind the planes must also be designed in such a fashion that easy exits can be made from all cockpits.



Wide World

U.S.S. "SARATOGA" AT MANEUVERS OFF HAWAII, WITH SQUADRON OF PLANES READY TO TAKE OFF

When one thinks of landing in a restricted area, one automatically thinks of an autogyro, and the question arises, why not use such machines aboard carriers? They have been landed aboard the *Langley* with no difficulty. In a strong wind, of course, it might even be necessary to land such an aircraft with considerable forward speed in order to prevent it from touching the deck while moving backward. After taking the autogyro aboard, however, what has one got from a military point of view aside from its slow landing speed? The capacity of the carrier would be materially reduced, although it is understood that a folding rotor has been developed which will alleviate the stowing problem somewhat. The offensive power of the autogyro would appear to be limited because of the rotor arc, which would prevent the use of machine guns in the vertical direction. The fighting plane of today is required to be extremely maneuverable. It is questionable whether or not the autogyro could go through the evolutions performed in military warfare.

It might be argued that the ability of the autogyro to hover would be beneficial in photographing or for observation purposes. However, the accuracy of modern anti-aircraft fire has made it extremely unhealthy to stay in one position under 15,000 ft. This is too high for accurate observation, and, unlike the Army, the Navy has little need for photography. As a matter of fact, high speed means safety for even this type of work.

WING-SPAN LIMITATIONS

The wing span of the carrier plane is also definitely limited by the size of the elevator which lowers the plane to the hangar deck when it is to be worked on or stored. If a plane has a large wing span, it must have folding wings. This will quite definitely eliminate the modern monoplanes, which make such good speed. It is doubtful if many designers would care to construct such aircraft with hinged wings. At present, torpedo and bombing planes with folding wings are used. They must be easily broken down in order that they may be quickly stowed in the smallest possible space.

Multi-engined aircraft have not been generally used aboard carriers. As a rule only large planes are provided with more than one power plant, and we have seen that size is of necessity restricted. Moreover, a skidding landing aboard a deck invariably results in a wiped-off landing gear. With multiple engines it is often difficult to keep the engine speeds synchronized, and this may easily result in such a landing. A multi-powered plane for carrier use would probably be more feasible if the design provided for tandem-mounted engines.

Aircraft manufacturers must not forget that the carrier plane never escapes the effect of weathering. While there is a hangar deck aboard, it is used mostly for repair work, and no effort is made to stow planes there when not flying. It would require too much time to prepare them for flight. Instead they are secured topsides, where they are exposed to all types of weather. Protected only by engine and cockpit covers, it is nevertheless required that they always be in good flying condition. Salt spray is frequently thrown over the planes, and the corrosive effect of sea water is too well known to require discussion. As a matter of fact, magnesium cannot be used to advantage in the construction of engines and aircraft for naval use because of the corrosive action set up by the salt air on that metal.

SECURING PLANES TO THE DECK

The planes are firmly secured to the deck by means of special forms of eyebolts which are placed in small wells in the deck. These eyebolts are scattered so thickly that one can always find plenty of them no matter where his plane is to be secured. A line is run to each wing, one to the tail skid, and one to the propeller hub. In addition, battens are secured to all the controls to prevent them from moving about in the wind. When the aircraft are secured for sea a windbreak is provided forward on the flight deck consisting of heavy planks inserted vertically in the deck and approximately 4 in. apart. This serves to effectually break up the force of the wind so that it can do no damage to the machines. The "island" affords protection on the starboard side. The safety nets are swung upward on the port side and provide a 6-ft barrier or windbreak.

DIFFICULTIES RESULTING FROM PITCHING AND ROLLING OF CARRIER

The normal rolling and pitching of a ship does not offer as many difficulties to the carrier pilot as one might suppose, although, as in everything else, extreme conditions might easily present a hazard. Some pilots would rather go aboard while the ship is pitching, while others would prefer rolling, if, of course, they were to have a choice. It is highly improbable that a pilot can invariably adjust his approach in order that he may land while the deck is level. Unless the carrier is of very short length it is not likely that she will pitch severely, for the greater the number of waves that support a ship, the less will be her tendency to respond to the falling away of a wave at either the bow or stern.

Perhaps as the plane is about to land, the deck will fall away from under it. The aircraft is then left for an instant hanging high in the air with little, if any, flying speed. Naturally, a hard landing results. Of course, just as frequently the pilot will find the deck raised somewhat higher than he had anticipated, and the wheels will touch somewhat sooner. If an entirely clear deck were used, the pilot could land somewhere near the center of the deck in an area of relatively little movement. Little if any trouble is experienced from this source, although the plane design must be such as to provide for some unusually hard landings.

Rolling, of course, will create a situation somewhat similar to landing on the side of a hill. While this is generally avoided by a pilot on a field if he has any choice, the carrier plane is arrested before it can groundloop severely. The design of ship stability can assist in eliminating the rolling to some extent. Huge gyros might also be installed in the carrier, but there has been no necessity for such extreme measures as this for the roll

is seldom over 10 deg, and generally it will be far below this figure.

A safe landing aboard a carrier is the result of the pilot's being unusually alert for the period of the approach and during the actual landing, rather than the result of long experience in this type of flying. A pilot may make a dozen good landings in a row and fail on the thirteenth merely because he has gained so much confidence that he has become careless. Lack of caution will result in a crash in spite of the best possible landing conditions. Some pilots make good landings from the very first, while others appear to never get the knack of it. In reality it is lack of concentration.

FLUSH-DECK OR "ISLAND" TYPE OF CARRIER

Whether the flush-deck or the "island" type of vessel is better suited to the needs of an airplane carrier is a much-mooted question. There are ardent advocates of both. The "island" consists of the ship control stations, guns for protection, and stacks for the flue gases. With a high bridge undoubtedly the commanding officer is in a much better position to control not only the ship but the planes which are being taken aboard or launched. Also, this construction permits the use of turrets which can train to either beam and so provide a greater total weight of gunfire wherever desired.

Exhausting the boiler gases directly over the firerooms is obviously superior to running them aft through living spaces. Life then becomes more comfortable for the personnel. Moreover, when the smoke is emitted from well aft at some relatively low point, it frequently blows directly astern and creates a condition of low visibility and rough air for the landing plane.

It is true, also, that to a certain extent the "island" creates rough air currents during gusty winds. Particularly would this be so if the landing area were to be in the lee of the "island" during a sudden shift of the wind. However, this condition has never proved to be too troublesome.

One might wonder whether or not the "island" would be a source of worry for the pilot during the landing. Although planes do sometimes land rather close to one edge or the other, this is the exception and most landings are down the centerline of the deck.

It makes no difference whether the "island" is placed on the port or the starboard side of the vessel. As a matter of fact, the majority of pilots are unable to tell offhand which side of the plane they look over when they land.

THE AMPHIBIAN PLANE IDEAL FOR USE ABOARD AN AIRCRAFT CARRIER

Obviously, the amphibian type of plane is ideal for use aboard the carrier because it provides the safety factor over water offered by the seaplane and still is able to land aboard. On the other hand, the performance of an amphibian craft is seldom outstanding from a military point of view. A relatively small, high-speed, seaworthy amphibian could be used to good advantage.

The United States has a total of 55,000 tons remaining which may be devoted to airplane carriers. The *Ranger*, of 14,000 tons, will be completed in 1934, and will be the first ship our Navy possesses that was designed as a carrier. By scrapping the *Langley*, whose slow speed of 14 knots makes her a useless appendage to the fleet, we should be in a position to construct six airplane carriers and thus live up to the 5-5-3 ratio allowable. At present Great Britain has five excellent carriers, while Japan possesses four.

The number of aircraft which can be carried by the fleet will have a tremendous bearing upon any campaign the safety of the country demands that it engage in. Their function will be to scout, observe, bomb, and offer protection to our own forces. Particularly will the need for the maximum number of planes be apparent when a naval action takes place outside the range of shore-based aircraft. It is more than likely that any engagement the United States Navy might take part in would be of this type. It is essential to the safety of the fleet, and hence of the nation, that the Navy take the greatest possible number of aircraft to sea. To do this we must build up to the deck tonnage allowable by treaty.

THE FLYING-DECK CRUISER

A further development of the carrier idea has come into prominence of late with the flying-deck cruiser. Although an experimental vessel that has yet to be built, it is rapidly gaining converts as it will permit us to overcome our inferiority in carrier tonnage. By "inferiority" is meant that four smaller carriers of the same total tonnage would be preferable to the two large ones we now possess. This new type of vessel is merely a normal cruiser which is provided with a landing deck sufficiently large to handle from 24 to 36 aircraft.

Under the terms of the London Treaty this nation is permitted to construct flying decks on not over 25 per cent of its cruiser tonnage. This would give us 80,000 tons, or a total of eight 10,000-ton ships. The addition of the flying deck would reduce the armament of these ships from twelve to nine 6-in. guns. Thus, a fleet of eight such cruisers would suffer a loss of twenty-four 6-in. guns, but would add 160 airplanes—an enormous gain in offensive power. Not only is this equivalent to two normal carriers, but best of all it would provide eight more landing decks for the fleet-based aircraft, and so increase the efficiency of naval aircraft as a whole. This would contribute safety and flexibility to the aircraft squadrons.

Thus, the airplane carrier, which had such an inauspicious beginning, has now reached a position of extreme importance. An effort has been made to give the aeronautical industry some idea of the problems which are encountered in sending aircraft to sea with the fleet. Realizing that the Navy is a first line of defense of the country, and that aviation is playing a more important role from day to day as strategical plans evolve, it is to be hoped that the aeronautical industry and its allies will work with renewed vigor to produce for this nation aircraft of increasingly better performance.

Modern Research Organizations and the AMERICAN PATENT SYSTEM

By FRANK B. JEWETT[1]

IN MEETING here today to celebrate the opening of the new Patent Office, we are, I think, taking part in something which is much more than merely the house-warming festivities incident to the occupancy of a new domicile. If my picture of the years ahead is at all correct, we are in effect marking the advent of a new era in the development of the American patent system. It is because of this feeling, and of my belief that the modern industrial-research organization and the results which flow from its operations are destined to have a profound effect on the further development of that system, that I chose as my topic tonight "Modern Research Organizations and the American Patent System."

While this is neither the time nor place appropriate for a historical review of the development of the American patent system or the relation of our Patent Office to that system, I cannot refrain from passing a comment or two on the profound influence which the patent structure has had on our national development since the days when the Constitution was written and provision was made in it for the granting of patents. The patents there contemplated were not patents of nobility in any heraldic sense, but were to be patents establishing property rights to new and useful inventions, accorded by the sovereign government as an incentive to the exercise of creative imagination. The men who wrote the patent provision into the document which was to be the fundamental law of the nation were men of vision, who saw not only the tremendous stimulus to an ingenious people which such a patent system would provide, but, beyond and above that, the enormous advantage which would accrue to the nation as a whole as a result of the exercise of that stimulated ingenuity.

When the Constitution was adopted and the patent system inaugurated, the obvious intention was to stimulate the individual inventor to create new, useful things. His reward was to be his right to exclude others from the use of his creations for a limited period if he so desired. So long as inventions were largely concerned principally with rather concrete things specifically related to limited fields, it made little difference to the public whether the inventor exploited his own inventions or transferred his rights to others who possessed similar rights. In the period preceding the industrial-research laboratory, patentable invention was essentially a haphazard affair.

With the advent of the fully equipped industrial-research laboratory, patentable invention has become in large measure a matter of reasonably certain calculation. Further, many of the patents are likely to have a much wider control than those of the earlier period. These facts cannot help but raise questions as to whether modification in the property rights granted, in the rules for determining what is patentable, and in the handling of patents, may not be in order. One thing is clear, nevertheless, and that is that the incentive of the patent system is still potent in the production of new, useful things, the net results of which are of great value to the public.

That the anticipations of those who drafted and adopted this provision of the Constitution have been amply justified is beyond question. Brushing aside the thousands of inconsequential patents which litter the records of the past and present and which are either the records of misguided ingenuity or the trivialities which always develop in the shadow of a great concept, and brushing aside also all of the criticisms, valid and invalid, which have been leveled against the patent system, the Patent Office, and the handling of patent litigation in the courts, we come to a net balance of huge proportions wholly on the credit side of the patent-system ledger.

VAST INFLUENCE OF PATENT SYSTEM IN STIMULATING INGENUITY

That the existence and operation of our patent system has had a vast influence, not alone in stimulating to the limit inherent ingenuity, but likewise in greatly accelerating the application of science to the affairs of every-day life, can hardly be controverted. Unless perchance one is endowed with the imagination of a Jules Verne, it is essentially impossible to conceive of our present-day United States having developed in the

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Address on the occasion of the dedication of the new U. S. Patent Office, Washington, D. C., April 11, 1932.

[1] Vice-President, American Telephone and Telegraph Company, New York, N. Y.

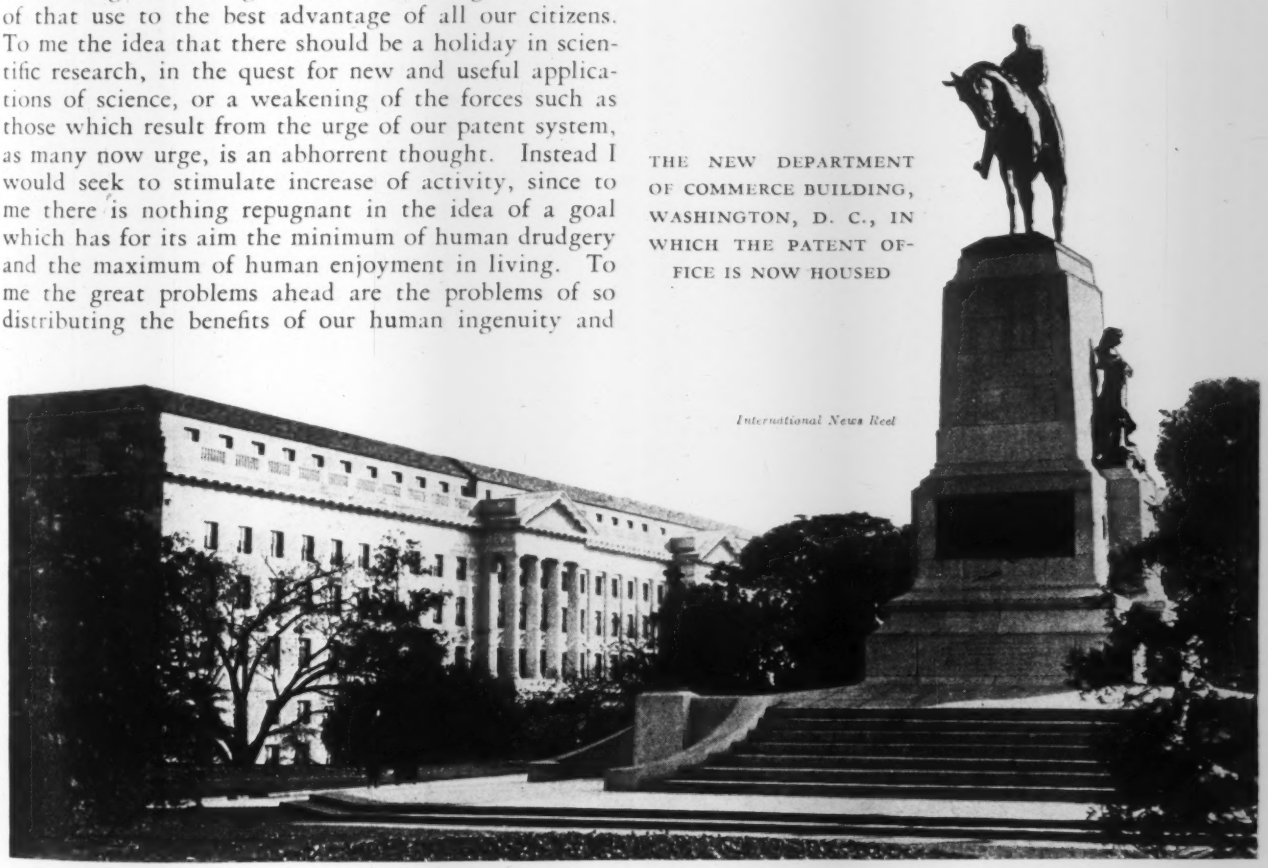
absence of our patent system. No mere flood of immigration, either of human beings or of ideas, however large, could within the space of a hundred and fifty years have transformed a meager agricultural body politic into the greatest industrial nation on earth.

Thanks to the workings of the patent system, there have been placed in the hands of our people, during this past century and a half, a vast array of new tools, for the most part labor-saving in character. These tools have enabled a new and relatively sparse population to subdue and develop a wilderness, and at the same time to do it under conditions which have raised the average standards of living and enjoyment of life to heights far beyond anything heretofore conceived possible or elsewhere obtained. That we have not always in the past utilized and are not now utilizing the things of our creation to the maximum advantage of the people in the matter of greatest happiness, contentment, or release from drudgery, is no basis for valid criticism of the patent system or its continued maintenance. Rather it is an indictment of our rate of progress as human beings in our social and political relations as regards the elements of greed and avarice, of lust for power, and of a just regard for the common decencies of living together.

In this respect our urgent problems of the present and the future are not concerned with stopping or diminishing the flow of new things into the current of life's activities, but are rather those of finding the best way of utilizing these things and of distributing the benefits of that use to the best advantage of all our citizens. To me the idea that there should be a holiday in scientific research, in the quest for new and useful applications of science, or a weakening of the forces such as those which result from the urge of our patent system, as many now urge, is an abhorrent thought. Instead I would seek to stimulate increase of activity, since to me there is nothing repugnant in the idea of a goal which has for its aim the minimum of human drudgery and the maximum of human enjoyment in living. To me the great problems ahead are the problems of so distributing the benefits of our human ingenuity and of so educating people in the profitable use of these benefits and of the time salvaged from the mere daily operation of securing food, shelter, and raiment, that the sum total of our effort will be a happier world for our descendants than the one we now know. Only if I were a black pessimist convinced of man's inability to adapt new tools and forces to his own betterment would I even contemplate the thought of a cessation of our endeavor to progress in material things. But who with any reasonable understanding of what man has accomplished, particularly in the past fifty or seventy-five years, and possessed of even a modicum of logical thinking, can be such a black pessimist? To be such assumes man possessed of an intellect so constituted as to permit of vast achievements in mere material things, but without capacity to go beyond the act of creation into the realm of control. Surely none of us will admit such a limitation as to ourselves.

GROWTH OF PATENT SYSTEM AN EVOLUTIONARY PROCESS

Like the things which it has brought into being, the growth of our patent system has been an evolutionary process filled with mistakes and failures, but gradually developing on the enlarging foundation of tested experience. That we are still far from the end of the road in the handling of the patent system, none will, I think, deny. Many of us sense deficiencies which we should like to eliminate, and many would like to bring about



THE NEW DEPARTMENT OF COMMERCE BUILDING, WASHINGTON, D. C., IN WHICH THE PATENT OFFICE IS NOW HOUSED

International News Reel

this elimination at a faster rate than seems possible in human affairs. To my way of thinking, what we can and should do as regards those things which seem clearly susceptible of improvement, is to join in an honest study of them and in an equally honest effort to bring about gradual betterment. I would deprecate any attempt at rapid radical departure from the things which have been built up out of the toilsome experience of the past. The forces and reactions are too vast in number and too uncertain in their collateral effects to insure that radical changes will bring about certain betterment. Further, our very progress under the patent system has introduced in recent years new and as yet little understood forces which may easily outweigh the influence of those of our older experience.

All of this brings me more specifically to the subject-matter of this present discussion, namely, Modern Research Organizations and the American Patent System.

To understand clearly the present relation of industrial research to the patent system, and to attempt any appraisal of the influence which this new factor is likely to have on the development of the patent system, one must understand clearly just what we have in mind when we speak of modern industrial research, and just how and why this new thing has introduced factors different from those which existed prior to its advent.

THE INDUSTRIAL-RESEARCH LABORATORY AS IT EXISTS TODAY

The industrial-research laboratory as we understand it and as it exists today in its various stages of development in different industries, is merely an organization of intelligent men, presumably of creative capacity, specially trained in a knowledge of the things and methods of science, and provided with the facilities and wherewithal to study and develop the particular industry with which they are associated. In a word, the modern industrial-research organization is an industrial tool which we have evolved in the past half-century for the purpose of expediting the application of science to the common affairs of life. When properly organized, properly related to the other functions of its particular industry, and properly equipped with the right human beings, it is an instrument capable of avoiding many of the mistakes of a blind cut-and-try experimentation. It is likewise an instrument which can bring to bear an aggregate of creative force on any particular problem which is infinitely greater than any force which can be conceived of as residing in the intellectual capacity of an individual.

Even if there were nothing more than this involved in the introduction of research laboratories in the industrial machine, their advent would have a profound effect on the development of the patent structure. Their very extent and variety and the creative influence of coordinated team attack would inevitably bring about an enormous speeding up in the production of things coming within the purview of the patent system. In a word, in its simplest results the wholesale development of the industrial-research laboratory would bring about a tremendous increase in the number and variety of patentable things which, even if confined within the narrow limits of particular industries, would create vast changes in the industries, in the commercial relation of the units of an industry, and in the problems submitted both to the Patent Office and to the courts for determination and adjudication.

More powerful, potentially, even than this effect is a secondary influence, the growth of which as one looks into the future bids fair to have stupendous reactions not alone on the development of our patent system, but likewise on the very organization of society itself. Except possibly in the minds of a few scholarly philosophers, I doubt whether the existence of this secondary result was even sensed fifteen or twenty years ago. Certainly it could not have been pictured by those who wrote the constitutional provision or framed the first patent law.

In order to understand what this secondary influence is and to appraise and direct the power which is in it as a factor certain to influence the development of our patent system, we must go back for a moment to the conditions which existed in the years preceding the advent of the industrial-research laboratory.

NATURE OF THE INVENTIVE WORK IN THE CENTURY FOLLOWING THE ADOPTION OF THE CONSTITUTION

In the hundred years after the adoption of our Constitution, the vast and striking developments which followed in the train of the newly created patent system were in the main the result of ingenuity applied in assembling the known facts of science, which were the common property of all, into new and useful aggregations which would serve old ends in cheaper and more economical fashion, or they were the application of items of the common store of scientific knowledge to the production of entirely new tools. For the most part this work was done by those ingenious individuals whom we designate as inventors. Largely their accomplishments were the result of their individual efforts, aided possibly by those of a few menial helpers. As the units of industry grew in size and the country expanded in population, these inventors came in some cases to be associated in more or less coherent groups provided with ample manual and material assistance. Nevertheless even in these larger groupings the results were substantially those of rearranging existing knowledge which was common property. Relatively little fundamentally new scientific knowledge was created by the work of inventors, and the results of their work were substantially confined narrowly to changes in their particular field of activity.

In so far as inventive work in this era involved the patent system in all its ramifications, the problems were principally those of relating new creations to those already in existence. Largely they were those of determining whether these new things possessed those elements of novelty which came within the scope of the patent law and were so entitled to that limited property right which would influence not only the future welfare

of the inventor but likewise the future operations of those already engaged in the same field. Within a given industry itself the advent of a new patent in this era involved merely the welfare and development of the units which made up that industry. The clash of conflicting interests, when such arose out of patents, was confined almost exclusively within the industry itself. In a word, the granting of patents in one industry had very little direct effect on other industries.

CHANGES BROUGHT ABOUT BY THE ADVENT OF THE INDUSTRIAL-RESEARCH LABORATORY

With the advent of organized industrial research primarily as a means of speeding up the process of creation, and particularly in recent years as a result of growth, specialization, and intricate ramification of the activities of the industrial-research laboratory, this whole situation has been changed. The modern, well-organized industrial-research laboratory has not only implemented the industry with which it is associated with enormously powerful tools for its rapid and extensive development through the production of new things, many of which are susceptible of patent protection, but it has likewise provided industry with the means for expanding into fields which a few years ago were entirely beyond the limits of its normal activity.

The reason for this resides in the fact that the modern industrial-research laboratory, unlike its predecessor, the inventor or the group of inventors, instead of being concerned merely with the putting together of old things in new combinations, is itself in large measure the creator of new scientific knowledge, much of which is no longer common property but under the patent system belongs to its creators. Some of this new knowledge is merely that acquired in the first steps of investigating fundamental things discovered by the men in our colleges and universities, and which are themselves common property. Other knowledge thus acquired is itself of the very nature of basic information which may have a wide variety of applicability. With the growth and development of the industrial-research laboratory this is increasing in amount. In so far as the patent system provides the machinery for withholding temporarily the utilization of this knowledge by any one who desires to employ it, it elevates the creator or his assignee to a position of potential power over the destinies of many human activities.

Since all the values which reside in the claims of a valid patent are obviously of interest to the owner, it is inevitable that he will seek to capitalize these values in one fashion or another. Where these values pertain to the elements of his own business he is most likely to employ them in the furtherance of it, either by direct operation or by the licensing of others in his particular field for a monetary payment or for payment in kind under licenses from the outside. Where, however, the values reside in industries remote from the field of his primary interest, the course to full capital realization is not so clear. Occasionally the values may be of such a nature and so concrete and well developed as to permit a reasonably full return through the sale of rights to those already operating in the field of applicability. Usually, however—and this is increasingly true if the patented invention covers really fundamental concepts of wide potential applicability—full value is possible only as a result of further development work. The holder of such a patent is therefore confronted with one of two alternatives: either that of expanding his research and development work along by-product lines for the purpose of establishing the full value of his original invention, with the object of ultimate sale as patent property, or of expanding the scope of his business into the field of by-product applicability. This latter of course leads him to become a competitor in a field which may be entirely foreign to the scope of his primary business.

IMPLEMENTING OF INDUSTRY WITH POWERFUL BY-PRODUCT WEAPONS BY THE RESEARCH LABORATORIES

Thus we see that the growth of the industrial-research laboratory, established originally solely for the benefit of the industry by which it was supported and where it has already proved its great value, has automatically implemented industry with powerful by-product weapons. These weapons if improperly used may endanger the stability of long-established industries having no obvious association with each other. The larger, more efficient, and more numerous industrial-research laboratories become, the greater will be the effect of these secondary forces. This is not only because the number of inventions coming within the scope of the patent system will be largely increased, but also because it is the universal experience that, once embarked on well-organized industrial research, the path of this research leads ever farther back toward the fundamentals of science, and so to the discovery of patentable things having a wide variety of uses. Further than this, the fact that scientific research knows no artificial bounds as established by commercial organizations, combined with the fact that its power to produce is a mobile power of the trained scientific mind which can be effective in a variety of directions, makes of the industrial-research laboratory a potent offensive weapon if occasion demands the deflection of its main concern from one field of endeavor to another. The process of creating, developing, and maintaining efficient industrial-research laboratories is unquestionably destined to grow, and possibly to grow at an accelerated rate, if for no other reason than that of protecting industry against attacks from the outside by creating weapons for counter-attack.

Up to the present time industrial-research laboratories have been established and maintained largely for their primary function, namely, that of assisting in the development of the industry with which they are associated. Such by-product values as have developed have in the main had but an incidental repercussion in foreign fields. In some cases, however, these repercussions have already been substantial and have caused

material dislocations in an otherwise orderly field.

I think it is safe to say that almost any one of our great industrial-research laboratories could, if the occasion arose for directing its whole attention to an attack on the problems of some foreign industry, produce values within the patent system which would be a major threat to the stability of that industry. Put another way, it is quite within the bounds of possibility to conceive of a modern industrial-research laboratory, entirely unconnected with any particular industry, directing its engines of creation against various industries and creating values within the patent system of such importance as to develop major problems for each industry attacked. These problems might be either in the way of large monetary payments for rights or because of the development of new competing units. In such form the industrial-research laboratory would be the modern counterpart, in giant's clothes, of the free-lance inventor of an earlier time, with whom we are all familiar.

The foregoing is, I think, indicative of the change that is being wrought in the problems of industry and its management as a result of the development of the industrial-research laboratory. The new problems are not, however, confined wholly to the creators and users of the new knowledge. Every element and part of the machinery involved in the patent system, whether in the field of patent solicitation, the operations of the Patent Office, the courts of adjudication, or the law-making and law-administering departments of the Government, seems to me destined to be vitally concerned with the new situation.

PUBLIC INTERESTS DEMAND THAT PATENT OFFICE BE FACILITATED IN EVERY WAY IN ITS WORK

If the course of events is to be as I have pictured it, it is of the utmost importance, not alone to the creators of new things of broad applicability, but to industry and the public generally, that the patents which define the invention and provide it with property value should be as clear and definite as it is humanly possible to make them, and should be published with expedition. To this end all of us who are in any wise interested in the patent system (and to a large extent this means the public generally), should see to it that every reasonable facility is afforded the Patent Office for the prompt and effective discharge of its function; nor should purely dilatory tactics of any sort be tolerated by those seeking patent grants. Further, for those inevitable conflicts which find their way into the courts, public as well as private interest should demand a system which provides for prompt and intelligent adjudication.

Finally, if the whole industrial machine on which society depends is to function without unnecessary, violent, and erratic disturbances occasioned by the eruption, from a multitude of industrial-research laboratories, of a vast volume of conflicting patents, additional thought will have to be given to the administration of the property values which the nation bestows as incentives to creative productivity.

Already in numerous fields we are witness to the absolute necessity of industrial units compromising conflicting patents emanating from their industrial-research laboratories, if the industry as a whole is to survive. So far these attempts to compromise have frequently resulted in conflicts with laws promulgated at a time when this sort of necessity either did not exist or existed in negligible amount.

Put in summary form, the things which the industrial-research laboratory is bringing into the patent system and which are destined to alter both its internal relations and its entire relationship to the rest of the social fabric, are the kind and character of its products and the method of their creation.

When the Constitution was adopted and the patent

(*Continued on page 450*)

PUBLIC SEARCH ROOM OF U. S. PATENT OFFICE, ACCESSIBLE TO ANY INVENTOR, MANUFACTURER, OR PATENT ATTORNEY, WHERE MAY BE FOUND, CLASSIFIED, ALL U. S. PATENTS, AND PRINTED PATENTS OF ALL FOREIGN COUNTRIES

Photo courtesy Patent Office

JOHN FITCH:

Patriot, Martyr, Pioneer Steamboat Inventor

By WM. H. RICHARDSON[1]

JOHN FITCH (1743–1798) was the first American to formulate plans for a steamboat, and the first American to coordinate the principles of steam navigation and prove his invention in the production of at least three boats that measured up to the standard of successful achievements.

Connecticut took the lead, in 1887, in memorializing her son, John Fitch, as "the first to apply steam successfully to the propulsion of vessels through the water." In 1902, Pennsylvania marked the spots where Fitch first conceived his idea and where he launched his first brass model with wooden side-paddle wheels.

Trenton, in 1921, set up at the focal point of "John Fitch Way," the scenic boulevard along the Delaware, a boulder bearing a tablet commemorating the site of the New Jersey terminal of the first merchant-marine highway in the world.

Congress, in 1926, belatedly bestowed still other honors upon Fitch that climaxed in the stately memorial at Bardstown, Kentucky, with its graven tribute to the man whose genius really *did* render the service to humanity it perpetuates.

The John Fitch whose life we can touch upon so casually in this study was not the querulous, eccentric, uncouth, ungrammatical individual his detractors would have us believe, but a man of intense earnestness. His wanderings led him into the most thrilling adventures with Indians—as well as whites—of which he told with an amazing modesty, and with unchallenged verity.

In April, 1785, John Fitch was walking with a friend along the State Road near Neshaminy, Pennsylvania, when a gentleman and his wife drove by in a "chair" or gig drawn by a fast horse. Fitch, limping with rheumatism contracted on one of his surveying expeditions, remarked to his companion upon the convenience it would be to travel without keeping a horse. The vision of our automotive age then flashed upon him, although at the time he was altogether unaware that such a thing as a steam engine or other form of motor had ever been invented.

THE FIRST MODEL BUILT

Learning that it had, however, Fitch saturated his mind with all the available literature on the subject, and presently, with the help of a friend, Nathaniel J. Boileau, he had his first model boat built, entirely of brass, except

TABLET IN HONOR OF JOHN FITCH AT MUNICIPAL DOCK, TRENTON, NEW JERSEY

the wooden side-paddle wheels. The priority of his invention of the side paddles is established by this experiment, even though he did decide later to abandon that form of propulsion and substitute therefor oars or paddles suspended from a frame.

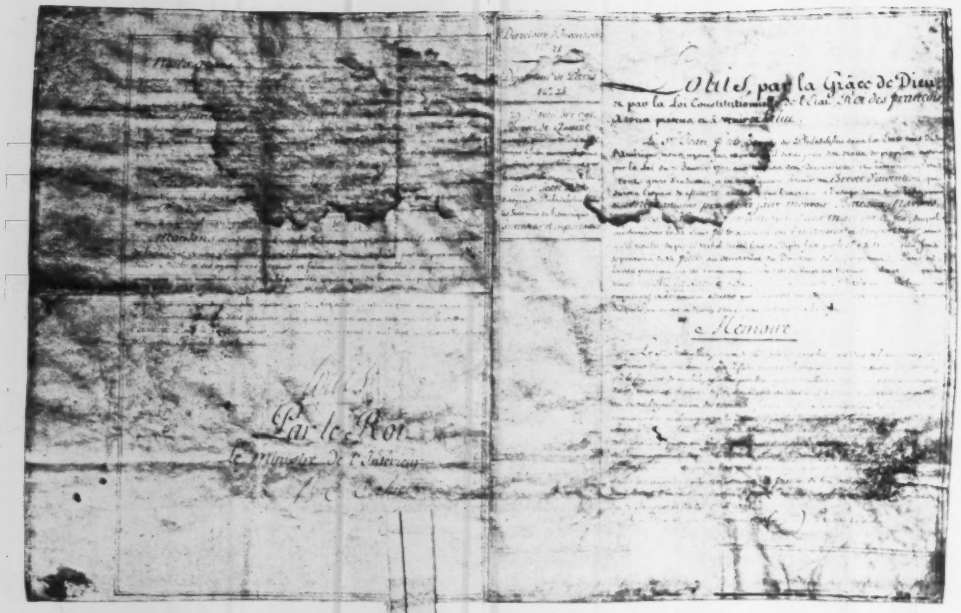
John Ewing, Provost of the University of Pennsylvania, and Samuel Smith, Provost of Princeton College, were both convinced by Fitch of the utility of his invention before he applied to Congress to protect him in its advancement. This application was dated August 29, 1785.

To the American Philosophical Society of Philadelphia, on September 27, 1785, and again on December 21, Fitch presented first the model, the drawings, and a description of a machine for working a boat against the stream (by substituting for the paddle wheels an endless chain, passing over screws or rollers, to which blades or floats were attached to serve as paddles).

The idea of first importance, as Fitch wrote in a letter to Benjamin Franklin at that time, was to get a steamboat going; and he hoped that Franklin would lend his friendly aid in introducing another useful art to the world.

Fitch started on a western journey on October 30, 1785. On the way he called on William Henry, of Lancaster, whose name has been overemphasized in connection with experiments made in 1776. Henry had made no demonstration of his idea, and since Fitch "had

[1] Department of Local History, Board of Education, Jersey City, New Jersey.



FRENCH PATENT GRANTED TO FITCH IN 1791, PP. 1 AND 4

first published his plan to the world," he said, "he would make no claim to the invention."

FITCH SEEKS WASHINGTON'S AID

From Lancaster, Fitch went down through Maryland, and on over to Mount Vernon. On Friday, November 4, 1785, Washington notes in his diary:

In the evening a Mr. Jno Fitch came to propose a draft and model of a machine for promoting navigation by means of a steam.

Washington received Fitch with courtesy, of course, and now that we have the evidence in the case all collated we can understand his lack of enthusiasm for Fitch's plans, since on September 6, 1784, as his diary states, "the ingenious Mr. Rumsey" had shown him his model of a boat "for ascending rapid currents by machinery." It was not, however, a steamboat.

Fitch left His Excellency after that remarkable interview "fully convinced," as he wrote, "that I could not interfere with Mr. Rumsey, otherwise the well-known candor of General Washington would have pointed out such interference."

Then Fitch went on to the legislature of Virginia to invoke their aid. James Madison presented his memorial. The committeemen spoke favorably of Fitch's project, but never made a formal report.

Congress had failed to give Fitch's project the support to which he was rightly entitled, so his new approach was through legislative grants from the several states. He unconsciously reveals to us the distinguished character and caliber of his friendships at Trenton when we find them joining in the following petition:

We, the subscribers, have examined the principles of the steamboat constructed by John Fitch, and are of the opinion that it may be a means of improving the navigation of these States to a great advantage and therefore deserves the protection and encouragement of the Legislature.

ISAAC SMITH
JOHN COX
SAMUEL STOCKTON
WM. C. HOUSTON
ROBERT PEARSON, JR.
STACY POTTS
JOHN CLUNN
SAMUEL TUCKER
RANSOLER WILLIAMS
JOHN STEVENS, JR.
WM. MCBEN
ABM. HUNT
THOMAS YARD
CHAS. CLUNN.

NEW JERSEY FIRST TO GRANT NAVIGATION RIGHTS TO FITCH

On March 18, 1786 New Jersey became the pioneer in befriending her adopted son John Fitch with the first state grant in her history. The legislative grant of that date secured to him for fourteen years

the sole and exclusive right of constructing, using and employing or navigating all and every species and kinds of boats or water craft which might be urged or impelled by the force of fire or steam in all the creeks, rivers, etc., within the territory or jurisdiction of this State.

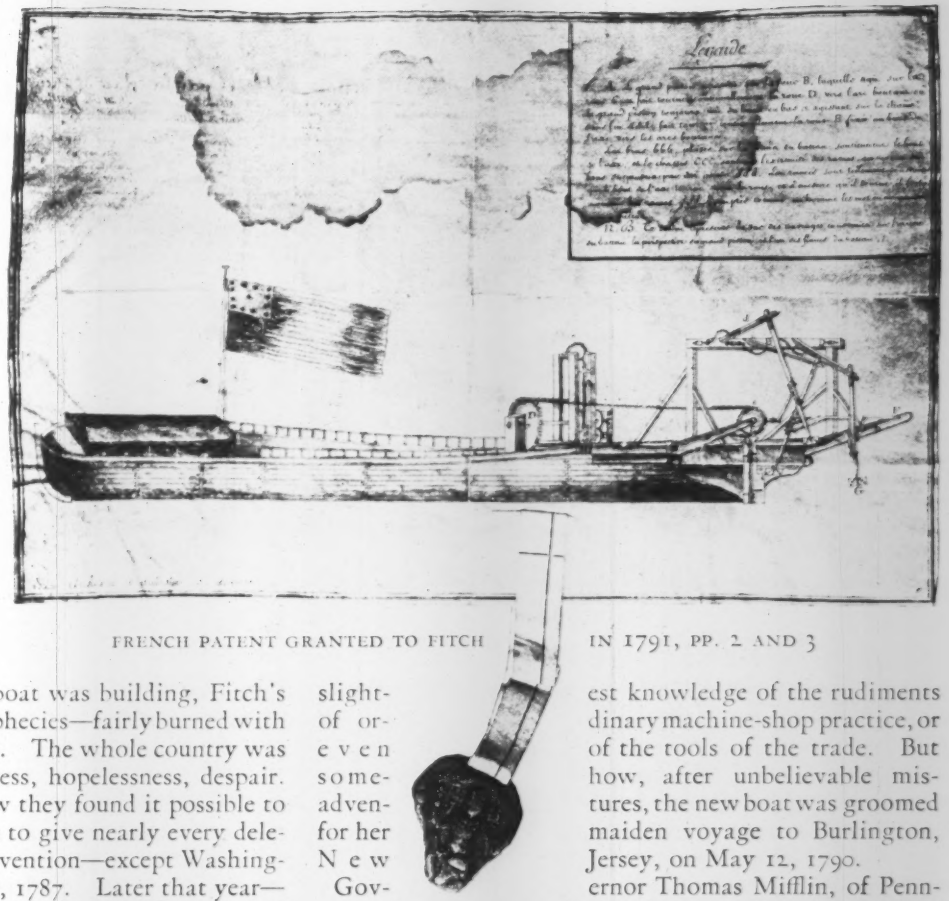
The grants of other states to Fitch were expressed in practically the same terms; Delaware awarded hers on February 3, New York on March 19, Pennsylvania on March 27, and Virginia on November 7, all of them in 1787.

The flotation of "The Steam Boat Company" to build their first real boat was started April 17, 1786. It is to be noted that all of these rather important state grants, with the exception of Virginia's, were made on the honor of John Fitch and the faith of the grantors in his plans.

Fitch obtained enough subscriptions in a week, and when he had $300 in cash accumulated, he started to build his steam engine. There were only three steam engines in America at that time—pumping engines—and they could hardly be said to have been of much use to Fitch in his steamboat plans.

Henry Voigt, a watchmaker, appears on the scene at this juncture. He first built a working model of the engine in brass, with a one-inch cylinder, upon which they expended $8. Next, they made the larger engine with a three-inch cylinder that was to drive the "small skiff" that became the germ of the steam navies of the world.

That engine cost $100. While it was building they pursued their experiments with various modes of propulsion, operating the boat by hand, until the idea of the cranks and canoe-like paddles was hit upon and incorporated in the first boat.



FRENCH PATENT GRANTED TO FITCH IN 1791, PP. 2 AND 3

FIRST TRIP OF THE PIONEER BOAT

On July 27, 1786, the first steamboat took her pioneer crew out from her pier and brought them back. John Fitch wrote his own Magnificat to his friend Stacy Potts at Trenton: he believed that they ran seven miles an hour; but they must have a new boat, of 20 tons burthen, with a 12-inch cylinder. Fitch was "as certain as anything can be that we shall not come short of 10 miles per hour, if not 12 or 14!"

The newly planned boat was to be 45 feet long and of 12 feet beam; the only known contemporaneous description of it is found in the *Columbian Magazine* for December, 1786. While the boat was building, Fitch's papers and letters—almost prophecies—fairly burned with his courage and determination. The whole country was then in terrible financial distress, hopelessness, despair.

Providence alone knows how they found it possible to finish that 20-ton boat in time to give nearly every delegate to the Constitutional Convention—except Washington—a ride on it on August 27, 1787. Later that year—in December—David Rittenhouse, Andrew Ellicott, and Dr. John Ewing gave their certificate of their belief in the boat's utility, as well as of their faith in the inventor.

SECOND AND LARGER BOAT NAVIGATES THE DELAWARE

In the meantime another and larger boat was projected. An 18-inch-cylinder engine was to be its motive power. In casting the cylinder, however, a defect rendered it worthless, and so the old 12-inch-cylinder engine had to be installed in the new 60-foot by 8-foot hull. In the new boat the three paddles "like snow shovels," hung over the stern.

This boat apparently made a trip from Philadelphia to Bordentown, New Jersey, near the end of July, 1788, before a defective pipe boiler—not of the design Fitch had approved—laid her up for repairs. Brissot de Warville tells us she ran on that trip twenty miles in three hours; and with the tide, eight miles an hour.

On October 12, 1788, the builders had entirely redeemed themselves. A passenger load of thirty persons steamed the twenty miles to Burlington, New Jersey, in 190 minutes, with a tide that set at two miles an hour. On the 16th, another distinguished company certified to the marvelous performance of the boat on the run to Burlington that day.

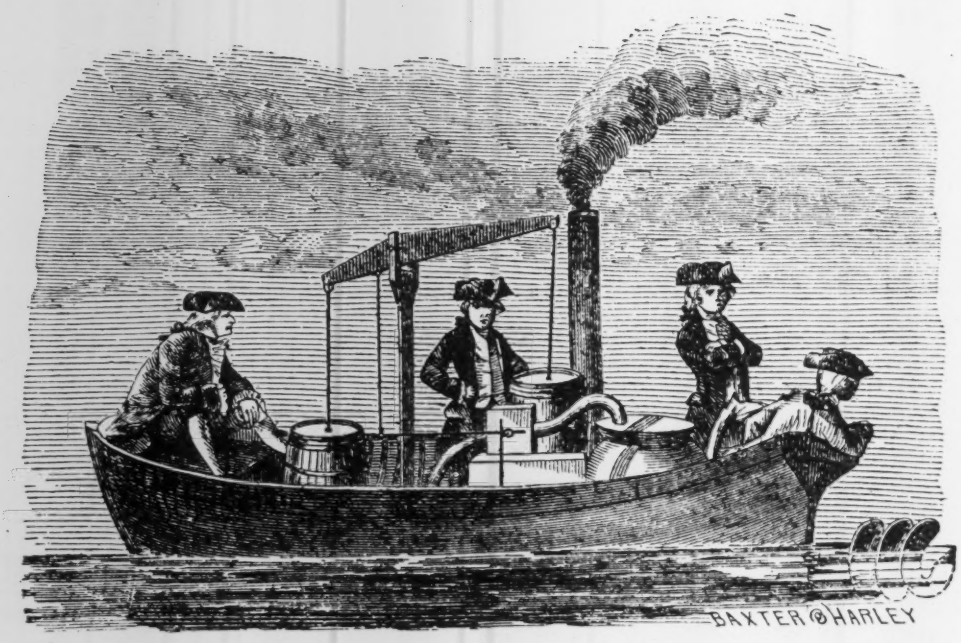
Early in 1789, work on the 18-inch cylinder was resumed, but troubles literally trod upon each other's heels. The best mechanics in America then were without the slightest knowledge of the rudiments of ordinary machine-shop practice, or even some of the tools of the trade. But adventure how, after unbelievable mistures, the new boat was groomed for her maiden voyage to Burlington, New Jersey, on May 12, 1790. Governor Thomas Mifflin, of Pennsylvania, and a most distinguished party were the company's guests on June 10, 1790. The boat's speed was officially determined that season at 8 miles per hour.

It has been estimated that Fitch's boat that season must have steamed between two and three thousand miles without material mishap, running on regularly advertised schedules from Philadelphia to Bristol, and to Burlington, Bordentown, and Trenton, New Jersey, besides making many extra trips to other points on the Delaware as far as Lambertville.

Is it any wonder that in 1857, Thompson Westcott, the foremost authority on John Fitch, grew indignant over the boastings regarding the performance of the Livingston and Fulton boat: 150 miles in 32 hours, seventeen years after Fitch's successes in steam navigation; Fitch's boat engined with the crude handiwork of American blacksmiths, and the *North River* (not yet the *Clermont*) by Boulton & Watt's best production in 1806!

Twenty-one years before the Livingston and Fulton steamboat monopoly had succeeded in sealing the commerce of the Father of Waters with their deadly exclusive grant, John Fitch had written these lines:

> It would require the aid of no more good men than would have saved Sodom and Gomorrah from fire and brimstone, to effect the greatest revolution which that (western) country ever did or will experience. . . I am determined that the navigation of the Mississippi and the Ohio shall be made easy. . . . I really pity men who have slaved at the oar these six thousand years past, and am determined to relieve them. . . I pledge my reputation, and you may esteem it as coming from an



FITCH'S SCREW-PROPELLER STEAMBOAT ON THE COLLECT POND, NEW YORK, 1796

honest man, that I will ascend the Ohio river one hundred miles in twenty-four hours!

That was John Fitch's futile argument before the legislature of Pennsylvania on November 7, 1790, when pleading for a grant for building ten boats costing $2000 each, to blaze the trail for the commercial generation of his America!

PLANS FOR FIGHTING VESSELS

It is interesting to recall that in his letter of June 29, 1792, to Dr. Rittenhouse begging for a pittance to keep life in his body, this versatile genius was proposing the equipment of men-of-war with steam engines for facilitating their evolutions in battle. This was twenty-three years before Fulton's *Demologos*.

The Barbary pirates were the public enemies then. Fitch said he could make the oars of his battleships work against them when the others were becalmed or in rough weather. He had a plan worked out for sweeping the enemy from the decks of their boats in 20 seconds, with a powerful stream of water from a pump with a six-foot cylinder and shot from a nozzle that would take a man off his feet at 40 or 50 yards. He thought a 20-gun steam-driven ship need never run away from a sailing ship of 100 guns.

"This, Sir," said the hungry, forlorn John Fitch in 1792, "whether I bring it to perfection or not, will be the mode of crossing the Atlantic for packets or armed vessels without interfering with a rope or a sail." That was 35 years before the *Savannah* steamed across to Cork with machinery designed and built by Daniel Dod, of Elizabeth Town.

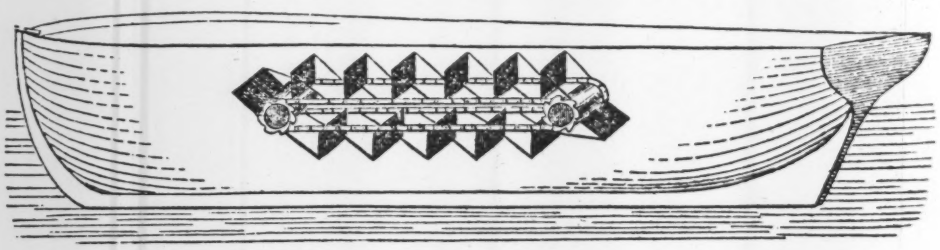
Then Fitch goes back for the last time to his other magnificent obsession, the peaceful penetration of the West; all he wanted now was sufficient to start navigation on the Mississippi. Fifty pounds advanced now would pay his debts and "complete the greatest undertaking, worthy of the notice of Mr. Rittenhouse; and with his name recorded that he was the man and (had) the honor conferred on him."

Nineteen years later, when the Roosevelt-Livingston Fulton boat slipped by Bardstown to claim the prize of the commerce of the Mississippi, as the *North River* had already secured that of the Hudson, they had forgotten John Fitch.

The indomitable Fitch gave way to despair when the "Commissioners for the Promotion of Useful Arts"—Thomas Jefferson, John Randolph, and Henry Knox—declared there could be no distinction in steamboat patents. Henry Knox was the minority member and a stanch friend of Fitch, whom

The Steam-Boat

IS now ready to take Paſſengers, and is intended to ſet off from Arch ſtreet Ferry in Philadelphia every *Monday*, *Wedneſday* and *Friday*, for *Burlington*, *Briſtol*, *Bordentown* and *Trenton*, to return on *Tueſdays*, *Thurſdays* and *Saturdays*—Price for Paſſengers, 2/6 to Burlington and Briſtol, 3/9 to Bordentown, 5/. to Trenton. June 14. tu.th ftf

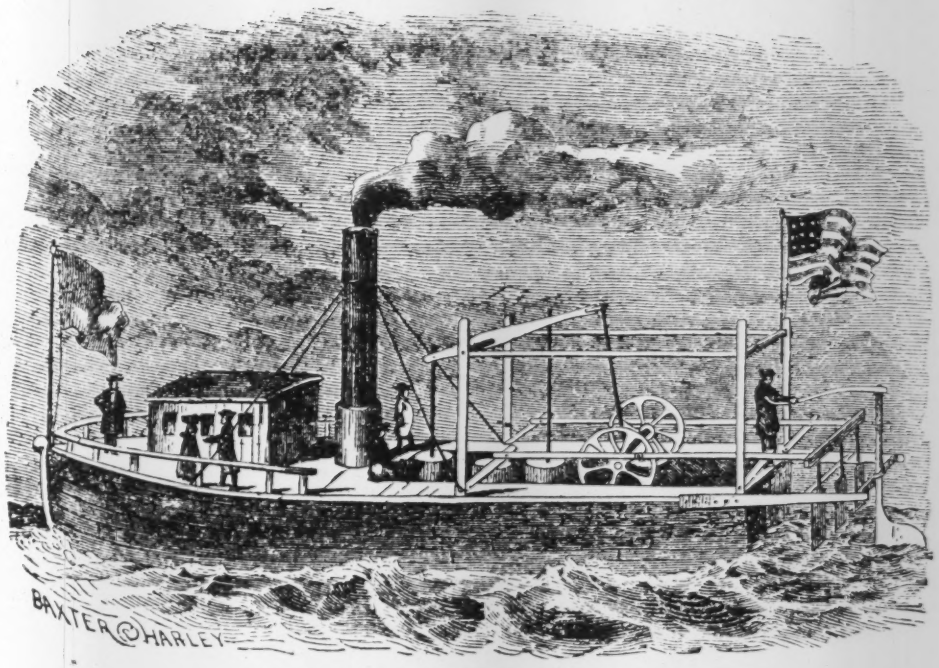


JOHN FITCH'S MODEL OF SEPTEMBER, 1785, WITH ENDLESS CHAIN, FLOATS, AND PADDLE BOARDS
(In possession of the American Philosophical Society.)

he had certainly known as Lieutenant Fitch when he was the armorer for the Flying Camp in the army in New Jersey in the summer of 1776.

FITCH GRANTED A PATENT

Jefferson and Randolph were partizans of James Rumsey of Virginia. In spite of Fitch's remonstrance that his application was dated August 29, 1785, and that he was the only one who had built and run a real steamboat, two patents were awarded, dated April 23, 1791, one to John Fitch and the other to James Rumsey. The texts of the two patents are precisely alike, except for the changes in names and other formalities. Virtually three-quarters of the claims set up in the patents as granted were Rumsey's, and the other quarter was Fitch's.



FITCH'S STEAMBOAT OF 1788, 1789, AND 1790

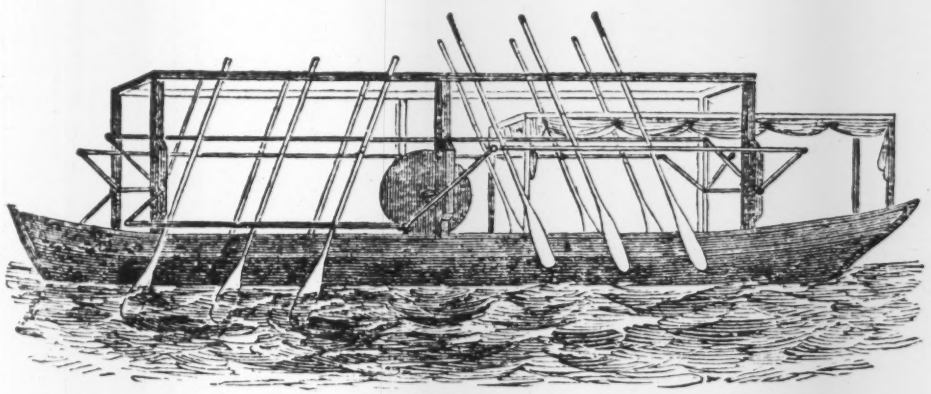
Fitch and his Steam Boat Company were in an infinitely worse situation with that sort of a patent than with the exclusive grants of steam navigation in the five states that believed in them. The moneyed men in the Steam Boat Company grew querulous, and Fitch was completely destitute. Then Mr. Stockton brought word that Louisiana would welcome the steamboat.

A new boat, the *Perseverance*, was then building. Fitch objected to going on with its construction unless his guaranteed stipend of 30 shillings a week (not sterling) was punctually paid, but the boat was ready for her trial on September 7, 1791, when he discovered that one of the directors had ordered, without consulting him, a wooden boiler case, and too short a one at that. More expensive alterations ensued, and work ceased until spring. Mr. Stockton loaned Fitch $40; the latter tried to borrow £50 from David Rittenhouse, without result; he then appealed to Richard Wells for $10, apparently also in vain. John Fitch had become a pest; it had become "disreputable" to recognize him; he was frankly discussed as demented, a lunatic. The *Perseverance* was abandoned, and four years later the engine and appurtenances complete, including the copper boiler, etc., etc., were sold at public auction.

EXPLOITING THE INVENTION ABROAD

All America was still too poor to maintain one steamboat when, on March 16, 1791, John Fitch and the majority interest of "The Steam Boat Company in America" organized a minutely detailed plan for patenting and exploiting John Fitch's steamboat in France, Holland, Germany, Prussia, Russia, Denmark, Sweden, the Republic of Geneva, and the Swiss Cantons.

The original Fitch-Vail agreement itself is among the priceless relics still preserved by the Historical Society of Pennsylvania in Philadelphia, and it is fundamental in establishing the eminence and priority of John Fitch, not only as an engineer and inventor, but as the author of the first program for the peaceful invasion of the European Continent.



JOHN FITCH'S STEAMBOAT OF 1786–1787

Aaron Vail, United States Consul at L'Orient, France, was made the agent abroad. On November 20, 1791, he secured an "invention patent" for fifteen years' duration for the exclusive privilege of constructing, vending, and employing Fitch's mechanism for propelling boats, ships, and other vessels. The complete drawings, papers, and plans of Fitch in this epochal and monumental enterprise formed part of the patent.

The originals or the legally requisite duplicates of these French papers are now in the National Museum, Washington. Our illustrations on pages 400 and 401 which reproduce this patent, are of interest in that they show clearly the use of the snow-shovel paddle mechanism at the stern of the boat. Interesting also to note is the flag of the United States floating over the craft, with its thirteen stars arranged in a parallelogram.

THE "TEAM" BOAT

In the winter of 1791–1792, John Fitch made the first written statement establishing his priority in the invention of the horse—or cattle—or team boat, as it is variously termed in his references. Cattle hitched to a large circular wheel laid horizontally furnished the motive power of the twin-hulled boats. Crude as it was, it really would have launched internal navigation and established cheap and dependable facilities at every river crossing twenty years before Fulton's activities in this direction.

On April 15, 1795, in the depths of his poverty, Fitch was endeavoring to induce Colonel Stevens to buy for $20 not only a four-tenths interest in his patents for the team boat, but his New York legislative grants of rights on the Hudson and the Raritan that then had six years to run!

MEMORIAL TO FITCH AT ENTRANCE TO CAPITOL BUILDING, HARTFORD, CONN.

Fitch proposed running such a boat to Albany, a voyage that would take two days. He submitted complete plans for the boat, with estimates of construction costs and operating expenses; he insisted it would clear $40,000 profit in ten years. He knew how few steam engines there were in the world; how hard they were to build; how hungry the world was for transportation facilities that would surpass the ox team, the stage coach, or the shallops that sailed our inland waterways.

The team boat was resorted to by Colonel Ogden in 1812–1813 when Livingston and Fulton were endeavoring to put the *Sea Horse* out of commission, as well as by Colonel Stevens in 1813 when the same men had driven his *Juliana* off the Hudson, pursued by six barge loads of New York harbor police.

It was in 1792, when "he loitered about Philadelphia for some months, an abject, despised, insulted, heart-broken man," that Fitch plunged into the preparation of papers covering his whole career. These were used by Thompson Westcott as the basis of his "Life" (1857), and are still accessible to students in the Ridgway Branch of the Philadelphia Library, through whose courtesy the author has had the high and honored privilege of examining them.

The papers were to be kept under seal for thirty years after his death. Certain contingencies under which the seal could be broken and the papers scrutinized were provided for. That moment had arrived in 1815, and the John Fitch papers became of central importance in the "Steam Boat Hearing" in Trenton that year.

FITCH IN FRANCE

John Fitch sailed for France in 1793, in the hope of prosecuting the steamboat enterprise under the agreement with Vail. The troubles culminating in the French Revolution had already begun; no one had any thought for business—and it is conceivable that any patent, or agreement with the King's ministry, in 1791, was not popular with the reds of 1793! Fitch's means, as well as his patience, were soon exhausted, and before leaving France for England he deposited his papers and specifications with Mr. Vail.

The testimony incontrovertibly organized by Westcott (pp. 387–390) proves that in 1795 Robert R. Livingston and Fulton, the latter soon to declare himself a "citoyen" of France, had possession of all these drawings and specifications of Fitch's for several months.

Fifteen years afterward, in 1810, the broad-visioned scheme of John Fitch for the European expansion of his steamboat plans that are now known to have been in the possession of Livingston and Fulton and to have undergone absorption by them had a curious recrudescence. One of Fulton's favoring biographers (H. W. D.) tells us that that year was "the heyday of Fulton's mental and commercial activities...." He "meditated nothing less than the introduction of steam navigation throughout the civilized world." As to this, Westcott says: "Fulton...[who] appropriated to himself the principles

(*Continued on page 442*)

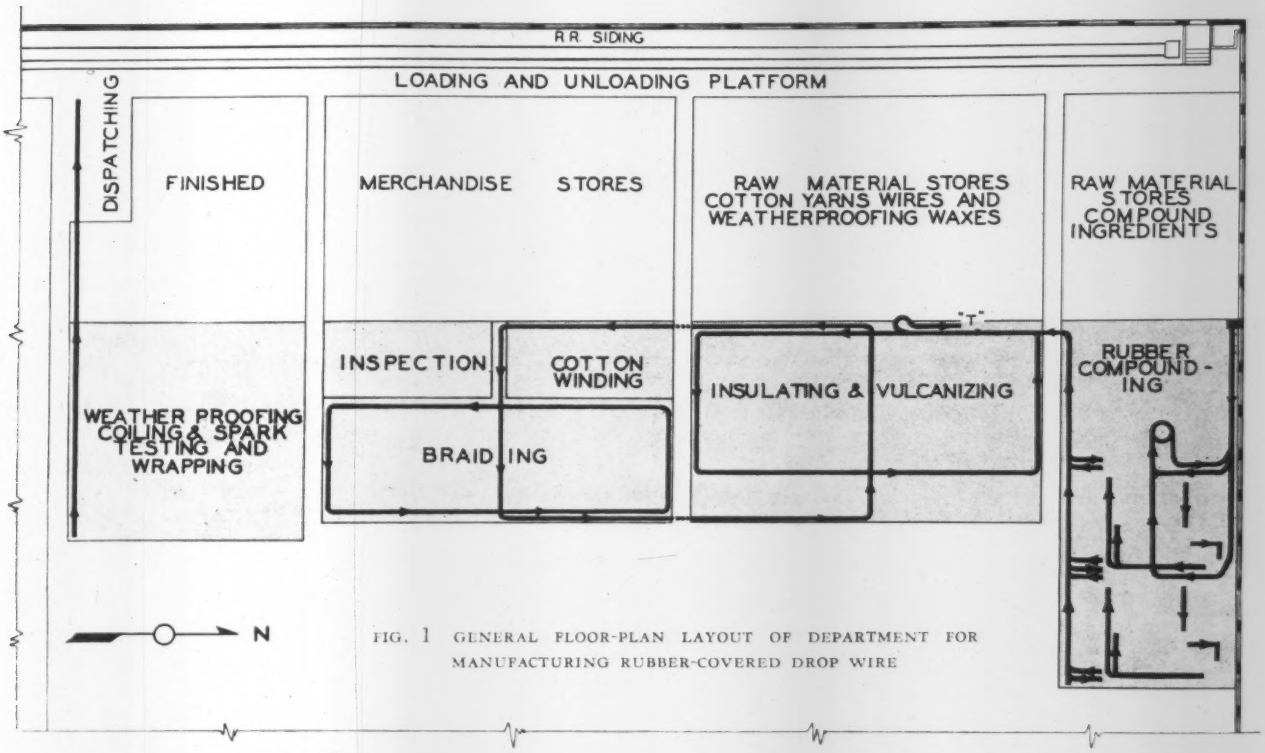


FIG. 1 GENERAL FLOOR-PLAN LAYOUT OF DEPARTMENT FOR MANUFACTURING RUBBER-COVERED DROP WIRE

The Manufacture of RUBBER-COVERED WIRES *for Telephone Installations*

By S. E. BRILLHART[1]

RUBBER-INSULATED wires are extensively used by the telephone companies in connecting up apparatus and equipment which is exposed to varying climatic conditions in the same fashion in which rubber-covered wires are employed by other electrical industries. In order to meet all size, strength, and electrical requirements the various wires available for use must differ widely from one another and from commercial rubber-insulated wires, in the character of insulation with which they are covered, as well as the properties of the conductors.

At one extreme this diverse group includes wires for such use as telephone drops which extend from the cable terminals to the buildings in which the stations are located. These drop wires must be capable of carrying heavy snow and ice loads in winter and also be able to withstand exposure to summer heat and strong sunlight in hot climates. They are Nos. 14 and 17 B. & S. gage hard-drawn copper and bronze conductors with insulations of relatively high quality containing more than 30 per cent of rubber and covered with a weatherproofed cotton braid. At the other end the group contains wires for connecting up instruments within buildings. Being supported frequently and protected from exposure, they are made from No. 22 gage conductors, insulated with a thinner wall and covered with a colored glazed cotton braid.

A new plant has been established at the Point Breeze Works,[2] Baltimore, in which certain unique methods and departures from conventional methods of manufacturing rubber-covered wires have been reduced to practice on a large scale. This paper purposes to describe the new plant.

The original installation has been set up to produce drop wires only. Briefly, in producing these wires at Point Breeze, the rubber-compound ingredients are first mixed, then applied

For presentation at the National Process Meeting, Buffalo, N. Y., June 6 to 8, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

[1] Chief of Department responsible for mechanical-engineering developments in rubber-covered-wire plant, Point Breeze Works, Western Electric Co., Inc., Baltimore, Md. Mem. A.S.M.E.

[2] The Point Breeze plant for the manufacture of lead-covered telephone cable was described by J. C. Hanley in MECHANICAL ENGINEERING, March, 1931, pp. 185–189; and the manufacturing processes employed there by John R. Shea in the April, 1931, issue, pp. 277–283.

FIG. 2 VIEW OF COMPOUND-MIXING SECTION

to the conductor and vulcanized in a continuous operation, after which a cotton braid is applied to protect the rubber covering from injury. The braid is weatherproofed with asphalt and wax to guard against its early deterioration and to further protect the rubber covering against premature aging by exposure to the active elements of the sunlight. The finished wire is inspected, coiled, and wrapped into toroidal coils for shipment.

PLANT LAYOUT AND MATERIALS-HANDLING METHODS

A single-story building of 300,000 sq ft floor area with M-type monitors has been erected which ultimately will be devoted exclusively to the manufacture of insulated wires. The rubber-covered-wire plant now occupies the northwest portion of this building.

The first section of the new plant, which has been equipped to produce only the drop wires required by the Bell Telephone System, has a capacity of 500,000,000 pair feet annually. It is now being expanded to include the manufacture of all other rubber-covered telephone wires required.

Substantial quantities of raw materials are required to produce even the volume of wire for which the original plant is equipped. For instance, 2,000,000 lb of rubbers, 2,100,000 lb of fillers, 6,200,000 lb of conductors, 1,500,000 lb of cotton yarns, and 2,700,000 lb of weatherproofing material are used annually. The floor-plan layout illustrated in Fig. 1 gives a general picture of the arrangement. Work in process of manufacture flows through the various machine sections progressively from north to south.

To begin with, the rubber-compound ingredients are brought from raw-material stores on their platforms, just as they were delivered there from the cars when unloaded, and delivered to the station partly shown in the lower left-hand corner of Fig. 2, where they are weighed into the type pans shown at the center of the same view in 450-lb batches. The ingredients used in small quantities are kept covered in the bins shown, to exclude foreign materials, and are separately weighed into smaller pans which are carried within the large batch pan. Thus the ten ingredients required are kept separated until the moment of mixing. The batch is so set up that suppliers' whole bags of filler can be transferred from the delivery platforms directly to the batch pan, and fairly uniformly cut slices of rubber added in the same way with very little additional weighing in.

After weighing, the entire handling through the compound mixing section is accomplished by a system of live- and gravity-roll, interlocking-pallet, and cleated-belt conveyors. The final gross weight of the batch is taken while the pan is resting on the scale section of the lower-level gravity-roll part of the system.

In order to start a weighed batch of compound ingredients on its way through the plant, the weighing operator pushes the batch pan free of the scale section in the lower-level gravity-roll conveyor which terminates in an automatically operated elevator. This elevator lifts the batch pan and discharges it to the upper level of the same conveyor system, by which it is carried to the loading platform of the internal mixer. The batches are dispatched alternately to one of the two mixers, their delivery being under the control of the last weighing operator who, when he releases the pan to the elevator, operates a push-button station which controls alligator switches in the upper level of the conveyor system at the points where the sections to the mixers branch off from the main line.

When the batch pan has been emptied by the operator at the internal-mixer loading platform he releases it to the return conveyor, which is of the live- and gravity-roll type, by which it is again delivered to the first of the weighing operators, to receive the next lot of raw ingredients.

After passing through the internal mixer, the batch is discharged into a short section of interlocking-pallet-type conveyor which carries it over and drops it into the rolls of the cooling mill. After cooling and sheeting, the compound is stripped from the mill manually in the form of rolls roughly 5 in. in diameter and 2 ft long. These are then individually carried to the supply table of the strainer by a narrow interlocking-pallet conveyor terminating in a special delivery mechanism which ejects the rolls on the table top close to the operator's left side, so that he can continuously feed them into the strainer.

As it is extruded from the strainer head, the compound is laid into a slow-moving interlocking-pallet conveyor which carries it overhead and starts it on its way to the accelerating mills. This section of conveyor terminates in a transfer mechanism under the control of the strainer operator, which can be seen in the middle distance of Fig. 2, and which makes possible the delivery of alternate batches to one or the other of two additional sections of interlocking-pallet conveyors located just over the accelerating mills. These sections feed the strained compound to the mills and their speed is so set that the time required for all batches to pass from the strainer to the mills is the same, so that likewise the cooling of all batches in transit will be the same.

After being stripped from the accelerating mills, the open-end reels on which the compound is now carried are manually

loaded on a cleated-belt conveyor, which raises them to the top-level double-deck overhead live-roller system, both levels of which are driven by a common belt. This top level terminates in a gravity-roller section which delivers them to a transfer operator, stationed at the point *T*, Fig. 1.

Here the operator transfers the full reels to pedestals mounted on the pallets of a carryall-type conveyor which passes around the outside of the insulating-machine area. Two stretches of this conveyor (see Fig. 3) are within easy reach of the insulating machines so that these reels may be conveniently obtained as required by the machine operators.

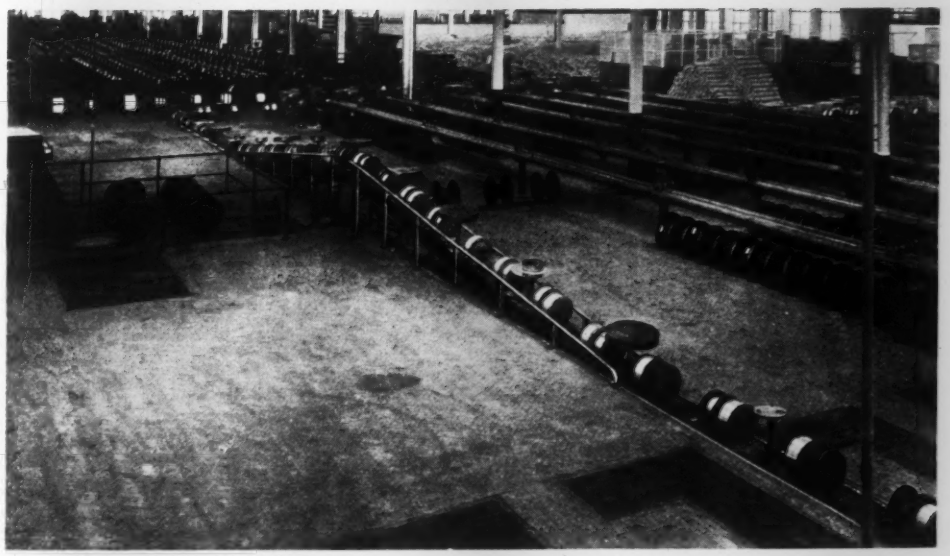


FIG. 3 INSULATING-MACHINE AND BRAIDER SECTIONS OF PLANT, SHOWING CONVEYORS

A similar carryall conveyor passes through the middle of the insulating area equidistant from either operating end, upon which the reels of insulated wire are loaded by the insulating-machine operators and from which they obtain empty reels as needed. This conveyor goes through the middle of the braiding area so that the porters can conveniently remove the insulated wire and load it into the braiding machines. Empty reels are returned to the insulating area from the braiders on the same conveyor.

A third carryall conveyor system, visible in the background of Fig. 3, loops around the outside of the braider section, receives the wire from the porters as it is removed from the braiders, and carries it to the edge of the weatherproofing section where it is removed and loaded into the weatherproofing machines.

The weatherproofed reels of finished wire are then rolled to the edge of the spark-testing and coiling area, shown at the extreme left of Fig. 4, where they can be conveniently loaded into the machines performing these operations. After testing, the coils of wire are placed in a rack, shown in the middle of Fig. 4, located between this section and the line of wrapping machines, where the wrapping operator can also conveniently reach them as required. The wrapped coils, which are now ready for shipping, are stacked on lift-truck platforms to the left of the wrapping operators.

MIXING THE COMPOUND

The compound-mixing equipment is grouped into units, two of which are now in operation. A unit consists of the following machines, named in the order in which they are used: One Banbury-type internal mixer; one 84-in. rubber mill for cooling and sheeting the compound after mixing; one 8-in. strainer by which extraneous material and foreign substances are removed, and two 84-in. rubber mills which are used for incorporating the accelerator, together with their associated stripping and reeling attachments for stripping the finished compound from the rolls and reeling it to the open-side reels used by the insulating machines.

Although the material is handled through the units in batches, the time cycle of mixing a batch and the association of the individual machines in a unit is such that the interval between batches is reduced to a minimum and practically continuous delivery of the mixed compound is obtained. The internal mixers are equipped with continuously recording temperature-measuring instruments, in order that the temperature of mixing may also be subject to control. Thus the two important factors of time of mixing and temperature of mixing are controlled in order that compound possessing uniform physical characteristics may be continuously mixed.

Inasmuch as the time of processing the batch through the other machines associated in the unit is controlled by the pace set by the internal mixer, it is necessary only to control the temperature of the mill rolls and stock screw in the strainer in order to insure uniform processing of the batches through these machines.

The accelerator, which makes possible the high-speed cure in the continuous-insulating machines, is added at the last moment and after the strained compound has been permitted to cool. As soon as the accelerator has been thoroughly incorporated, the compound is stripped from the mill rolls and reeled upon the open-side reels on which it is handled at the insulating machines.

The two-head stripping and reeling attachment used for removing the mixed compound from the accelerating mills in a band 4 in. wide by $^3/_4$ in. thick and for reeling it up is a new development. This mechanism makes it possible to remove the entire 450-lb batch in a continuous strip which is reeled alternately on one or the other of the two heads provided. The operator can remove a full reel, load it upon the cleated-belt conveyor, and place an empty one on the head while the compound is being run on the reel mounted on the other of the two heads.

INSULATING THE WIRE

In a conventional wire-insulating plant the rubber compound is manually fed into a forcing or tubing machine which extrudes it upon the wire. The conductor with its unvulcanized covering is received from the delivery side of the tubing machine and coiled in pans or wound on large steel drums which must later be introduced into a steam-vulcanizing oven where they are heated and the rubber covering vulcanized under steam pressure for several hours. When coiling in pans, the insulated wire is laid in a layer of powdered soapstone or

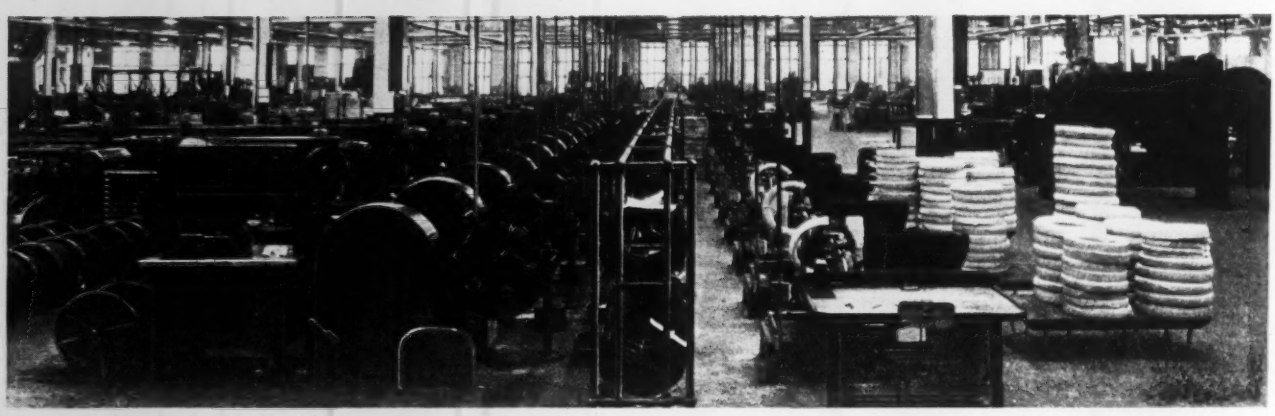


FIG. 4 COILING AND WRAPPING SECTIONS OF PLANT

sifted chalk and each flat coil of wire separated from the ones next to it by more of the same material.

This entire sequence of operations is performed in the new plant on a machine unit schematically shown by Fig. 5, which has been developed for insulating and vulcanizing the wire continuously in a single operation.

As performed on this unit the actual manual operation consists of supplying the reels of compound and bare conductor, which are automatically fed into the machine, and removing the reels of cured rubber-covered wire as they become filled. The path of the wire through the unit is from the reels mounted on the bare-wire supply stands into and through the insulating tool head attached to the cylinder of the tuber, wherein the compound is extruded upon it, into the steam-jacketed vulcanizing tube, out into the exhaust hood through the steam seal in cured condition, around the sheave in the hood and through the cooling spray back to the wire-drive capstan, and around this member to the insulated wire take-ups, where it i wound on the reels required for handling at the braiders.

As an indication of the output speeds obtainable with the unit, No. 14 code wire can be produced successfully at speeds up to 400 fpm. Nos. 19 and 20 gage wires are insulated singly at 600 fpm, and smaller gages, such as No. 22, having a considerably thinner wall of insulation, at 1000-fpm.

The process as a whole and the unit itself form the most important single machine development in the new plant, because they make possible close quality control by subjecting all the insulation to precisely the same curing conditions of time and temperature. Also, because by making possible close size control and relatively high productive outputs, they effect substantial economies.

In feeding compound to the machine a full reel is placed upon a pedestal mounted behind the wire-drive capstan and close to the throat of the tuber. The end of the strip of compound is introduced by the operator between a pair of toothed rolls of the automatic feeder and into the throat of the machine. Thereafter it is fed into the throat as required by the feeder, whose operation is controlled by the quantity of compound within the stock screw, which in turn depends upon the velocity of extrusion of the compound upon the wire.

The insulation is applied to the wire as it passes through the insulating-tool head attached to the delivery end of the tuber. In the conventional process of applying insulation, the operator controls the centering of the conductor within the covering by manually adjusting the location of the dies or wire guide tubes relative to one another at this point. In the continuous insulating process this centering is accomplished by depending upon the precise and entirely inflexible tool set-up used, whereby accurately machined dies and core tubes are inserted into the tool head in a positive keyed position when the machine is set up. Their location cannot be changed when setting up, nor subsequently adjusted during the operation of the machine.

As a result of using this accurate and inflexible tool head it is possible to continuously produce rubber-insulated wire with outside diameters only 3 per cent greater than the minimum permissible diameter, and without imposing a burden of watchfulness upon the operator.

As the wire leaves the die bearing the uncured insulation upon it, it passes directly into the vulcanizing chamber. In the conventional process of manufacturing rubber-covered wires the insulation is vulcanized in ovens heated with relatively low-pressure steam. This usually requires several hours. In the continuous process the entire vulcanization takes place in the time required to pass the insulation through the 100-ft-long vulcanizing tube, which, for example, in running No. 17 B.P. drop wire, is 16 sec. During this time the covering is exposed to an atmosphere of saturated steam maintained at a pressure of 200 lb per sq in. This high-speed cure is made possible by a well-balanced compound in which a very quick-acting accelerator is used.

When the wire reaches the exit end of the vulcanizing tube, with the insulation cured, it is passed out through a steam seal consisting of two radially slotted rubber disks, which are snugly pressed against the insulation as it moves along. When it is necessary to open the seal to thread up the machine the escaping steam is retained within the exhaust hood and drawn out by a fan.

A cooling spray is also located within this hood, through which the wire passes as it comes out of the tube. Evaporation of this spray water as the wire passes out into the room cools it and abstracts heat which otherwise might be retained after the wire is reeled up and thereby cause overcuring.

As the insulated wire is returned to the wire-drive capstan over sheaves attached to the top of the vulcanizing tube, it passes through a fault register where it is subjected to high voltage in order to discover and register any faults which may be present in the insulation.

Inasmuch as the angle of wrap of the wire as it passes around the drive capstan is only 180 deg, a formed rubber belt presses it against the surface of the capstan and assists in providing the necessary positive driving force to draw it through the machine at a constant velocity.

The finished insulated wire is taken up on a reel mounted

near the operating end of the machine. As a reel fills, the operator cuts the wire and transfers it to an empty reel while the machine is operating at full speed.

APPLYING THE BRAID

The cotton braid which covers the rubber insulation is applied to the drop wires on sixteen-carrier commercial rotary braiding machines and Western Electric high-speed braiders. The conventional braiders are operated at a head rotative speed of 160 rpm, whereas the Western Electric machines operate at 330 rpm.

Generally speaking, the high operating speed is made possible by the substitution of ball and roller bearings for the usual sliding-pair bearings found in conventional rotary braiders, by the elimination of reciprocating movements and the substitution of rotations for them, and by the employment of a means for maintaining constant the length of cotton strand from the point of take-off on the lower cotton package to the braiding point, so that the usual spring slack-taking-up mechanism for the cotton strands has been eliminated.

The most interesting substitution of rolling friction for sliding is that made in carrying the upper package carriers upon a ball-bearing-mounted roller which in operation is driven around the vertical wall of the track while the package itself is carried outside the wall.

WEATHERPROOFING AND FINISHING

The saturant and wax used to weatherproof and finish the braided wire are applied in an improved machine consisting essentially of two steam-heated tanks in which the materials are held at the proper temperature for application, through which eight separate wires may be passed simultaneously. In passing through the machine the wire is led from the supply reels into the tanks of saturant and about sheaves at each end, out of the bath and through a pair of rotating formed rollers which remove the excess saturant through a pair of similarly shaped waxing rolls which dip into, carry the melted finishing wax up from the tank, and apply it, into the cooling trough which is kept filled with artesian-well water, and between a multiplicity of friction polishing rolls in the trough, which give the wax the necessary finish, out of the trough and through air-jetted wipers which remove the water from its surface, about the drive capstan at the left end of the machine and to the take-up stands.

In the new unit, the materials are melted out of the drums in which they are received. A drum is placed in a lifting basket bottom up, and by means of an electric hoist on a swivel boom is lifted over and lowered into the steam-heated tank where the material flows out as melted. The melted material is permitted to attain the proper temperature for application to the wire before it is fed through a direct connection to the applicating tank, so that the temperature of the bath is not affected by additions to the supply.

This handling of the weatherproofing materials is typical of the fashion in which all manual lifting of heavy bodies has been eliminated throughout the plant. There is no lifting of heavy reels of wire at any point, all reels being rolled on the rims of their heads into and out of machines. The supply and take-up stands of all machines are equipped with ramps up which the reels can be easily rolled until their axles drop home into the proper position for paying off. This has naturally reduced the workers' fatigue considerably.

SPARK-TESTING AND COILING THE WIRE

In the new plant the operation of testing for faults is combined with measuring and coiling the wire and performed on a spark-testing and coiling machine. In operating this unit the reel of wire to be tested is mounted on the supply stand at the left of the machine, the wire passed up and over the upper of two sheaves above the bench top, thence horizontally through the upper electrode, around the reversing sheave and back through the lower electrode, around another sheave and between the counter rolls, and through the distributor arm to the take-up capstan, where the end is grounded and the wire is coiled ready for wrapping.

A high electrical potential is applied to the two lengths of electrode so that, as the wire is being coiled, a running test for continuity of the insulation is made. If a fault occurs, a current flows from the electrode through the fault to the grounded conductor, which serves to operate certain relays which in turn stop the machine at once, light a lamp, and sound a signal. The fault can then be patched or removed. If no fault is located, the machine continues to coil the wire until a predetermined length, in most cases 1000 ft, has been taken up by the capstan. It then automatically stops, and the operator cuts the wire, revolves the second of the two capstan heads into position for coiling, and starts the machine again, while he binds the coil just completed, removes it from the capstan, and places it upon the rack which separates the coiling from the wrapping section.

After spark-testing and coiling, the coils of wire are wrapped with creped paper on conventional wrapping machines such as are used for wrapping automobile tires, and are then ready for delivery to merchandise stock or shipment.

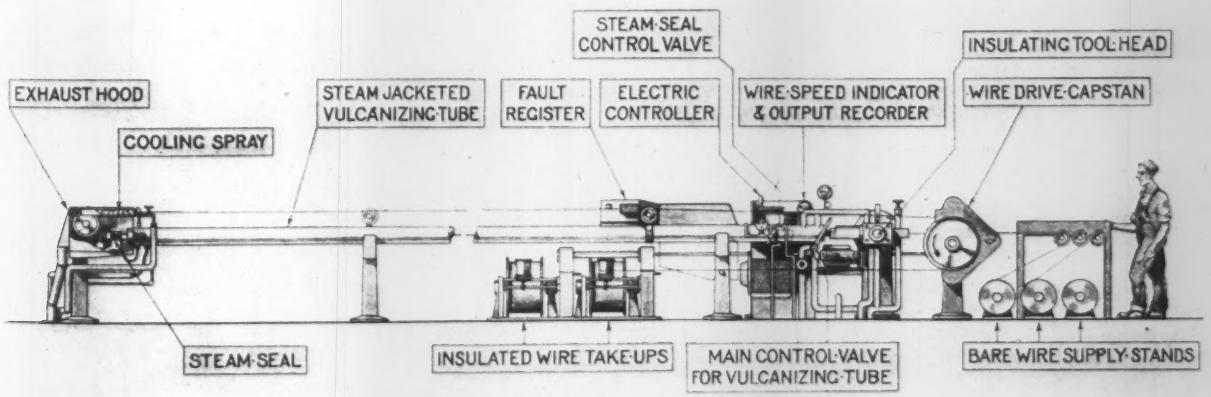


FIG. 5 SCHEMATIC DIAGRAM OF CONTINUOUS INSULATING AND VULCANIZING MACHINE

The Basic Laws and Data of HEAT TRANSMISSION[1]

By W. J. KING[2]

IV—FORCED CONVECTION

IT IS GENERALLY agreed that the study of forced convection began in 1874 with the work of Osborne Reynolds,[3] who was the first to point out the relation between fluid friction and heat transfer. Reynolds' work has been extended by one of his students, Royds,[4] who is the author of one of the very few books on heat transmission published in the English language. Significant contributions in this field have been made by a number of other British investigators, including Stanton,[5] Pannell,[6] Taylor,[7] and Davis.[8]

A number of very valuable papers and texts on this subject have emanated from Germany, particularly those of Nusselt,[9] Prandtl,[10] Gröber,[11] ten Bosch,[12] and Schack.[13]

Boussinesq[14] was one of the first to obtain a solution for the differential equation of heat flow to a moving fluid. In recent years Lévéque,[15] Roszak[16] and Véron,[16,17] and Margoulis[18] have made some important contributions to the French literature of forced convection.

In this country, the work of Professor McAdams and his colleagues at M.I.T.[19] is outstanding. Chester W. Rice[20] has contributed several well-known papers, and Colburn and Hougen[21] have published an excellent survey of the subject in connection with their studies of heat transfer in gas condensers.

Most of these investigators have been concerned with three major problems: (1) the derivation, by mathematical analysis, of general equations for calculating the heat flow, (2) the experimental determination of the individual surface-heat-transfer coefficients under various conditions, and (3) the development of methods for correlating the data so that the results may safely be extrapolated beyond the range of the experiments. Four methods of attack have been resorted to: (1) the integration of the differential equations of heat flow to a moving fluid, (2) dimensional analysis, (3) the analogy between the transfer of heat and of momentum, or the similarity of the temperature and velocity gradients, and (4) the relationship between heat transfer and diffusion. In some cases a fair amount of success has been attained, but in many others the results are far from satisfying. In order to solve the differential equations, simplifying assumptions have been made, which sometimes depart too far from the actual conditions. Dimensional analysis indicates how the variables ought to be grouped, but does not give the forms of the functions. With regard to the test data, it is frequently difficult to determine whether the discrepancies are due to experimental errors, dissimilar conditions, or differences in the methods of correlating or expressing the results. Almost every aspect of the subject is in need of more careful study more accurate measurements, and more complete data, covering a wider range of the variables involved. However, a broad foundation has been laid, and many interesting problems have been brought to light which deserve more attention from mathematicians and research engineers than they have been receiving.

Symbols and Units

The increasing use of *consistent* units provides a very valuable

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[1] Part I, a general survey of the subject, appeared in the March issue pp. 190–194; Part II, on Conduction, in the April issue, pp. 275–279, 296; and Part III, on Free Convection, in the May issue, pp. 347–353.

[2] Engineering General Department, General Electric Company, Schenectady, N. Y.

[3] O. Reynolds, Proc. Manchester Lit. and Phil. Soc., vol. 14 (1874), p. 9; "Scientific Papers of Osborne Reynolds," Cambridge Univ. Press (1901), vol. 1.

[4] R. Royds. "Heat Transmission by Radiation, Conduction and Convection," Constable and Co., London, 1921 (N. Y., Combustion Pub. Corpn., 43 Broad St.).

[5] T. E. Stanton. Brit. Advis. Comm. for Aeron. Rep. and Mem. No. 94 (1912–1913), p. 45; No. 243 (1916), p. 3, 19; "Dictionary of Applied Physics," Macmillan, N. Y., 1923, p. 401.

[6] J. R. Pannell. Brit. Advis. Comm. for Aeron., Rep. and Mem. No. 243 (1916), p. 9.

[7] G. I. Taylor. Brit. Advis. Comm. for Aeron., Rep. and Mem. No. 272 (1916).

[8] A. H. Davis. *Phil. Mag.*, vol. 40 (1920), p. 692; vol. 41 (1921), p. 899; vol. 44 (1922), p. 920, 940; vol. 47 (1924), p. 972, 1057; or Nat. Phys. Lab. Coll. Res., vol. 19 (1926), pp. 181–273.

[9] Wm. Nusselt. *Zeit. V.D.I.*, vol. 53 (1909), p. 1750; vol. 61 (1917), p. 685; Mitt. über Forsch. no. 89 (1910); *Techn. Mech. u. Thermo.*, vol. 1 (1930), p. 277; *Forschung*, vol. 2 (1931), no. 9, p. 309.

[10] L. Prandtl. *Phys. Zeit.*, vol. 11 (1910), p. 1072; vol. 29 (1928), p. 487.

[11] H. Gröber. *Forschungsheft* 130 (1912); "Einführung in die Lehre von der Wärmeübertragung;" J. Springer, Berlin, 1926.

[12] M. ten Bosch. "Die Wärmeübertragung;" J. Springer, Berlin, 1927; *Schweizerische Bauzeitung*, vol. 96 (1930), p. 325; *Zeit. V.D.I.*, vol. 75 (1931), no. 2, p. 40.

[13] A. Schack. "Der Industrielle Wärmeübergang;" Verlag Stahleisen, Düsseldorf, 1929 (Cleveland, Penton Pub. Co.)

[14] J. Boussinesq. *Comptes Rendus*, vol. 132 (1901), p. 1382; *J. Math. pures et appl.*, vol. 1 (1905), p. 285.

[15] A. Léveque. *Annales des Mines*, Series 12 (1928), 4, 5 and 6 Liv., pp. 201–415.

[16] Ch. Roszak and M. Véron. "Nouvelles Études sur la Chaleur;" Dunod, Paris, 1929.

[17] M. Véron. *Science et Industrie*, vol. 15 (1931), no. 212, p. 401, and no. 213, p. 463.

[18] W. Margoulis. *Chaleur et Industrie*, vol. 12 (1931), no. 134, p. 269, and no. 135, p. 352.

[19] (*a*) W. H. McAdams and T. H. Frost. *Jl. Ind. Eng. Chem.*, vol. 14 (1922), p. 13, 1101; *Refrig. Engg.*, vol. 10 (1924), p. 323.
(*b*) E. L. Chappell and W. H. McAdams. Trans. A.S.M.E., vol. 48 (1926), p. 1201.
(*c*) W. H. Walker W. K. Lewis, and W. H. McAdams. "Principles of Chemical Engineering;" McGraw-Hill, N. Y., 1927.
(*d*) W. H. McAdams. Mechanical Engineering, vol. 52 (1930), p. 690.
(*e*) T. B. Drew. "Mathematical Attacks on Forced-Convection Problems." A Review; paper presented at the Swampscott meeting of the A.I.Ch.E., June 11, 1931.
(*f*) T. B. Drew, J. J. Hogan, and W. H. McAdams. *Jl. Ind. Eng. Chem.*, vol. 23 (1931), no. 8, p. 936.
(*g*) T. B. Drew and W. P. Ryan. *Jl. Ind. Eng. Chem.*, vol. 23 (1931), no. 8, p. 945.

[20] C. W. Rice. (*a*) Trans. A.I.E.E., vol. 42 (1923), p. 653; (*b*) *Jl. Ind. Eng. Chem.*, vol. 16 (1924), p. 460; (*c*) "Int. Crit. Tables," vol. V (1929), p. 234.

[21] A. P. Colburn and O. A. Hougen. "Studies in Heat Transmission;" Univ. of Wisconsin Eng. Exper. Sta. Bull. No. 70, 1930; also: *Jl. Ind. Eng. Chem.*, vol. 22 (1930), p. 522.

means for comparing or converting the results expressed in any of the systems used in this country and abroad. Formulas or curves involving only dimensionless groups are immediately valid in any such system. However, it is sometimes very awkward to apply a single set of units to a variety of practical cases for which it is the common practice to use more convenient and familiar units. In the following general analyses any consistent units may be used where none are given. Specific formulas will be given later, for which the units are explicitly stated. The units given below are merely illustrative of a consistent system:

Dimensions: ft, lb, hr, Btu, deg F

C, C_p = specific heat (at constant pressure for a gas), $\frac{\text{Btu}}{(\text{lb})(\text{F})}$
d = diameter, ft
f = friction factor (dimensionless)
g = acceleration of gravity, ft/hr^2 (4.17×10^8)
h = surface-heat-transfer coefficient, $\frac{\text{Btu}}{(\text{hr})(\text{sq ft})(\text{F})}$
k = conductivity of fluid, $\frac{\text{Btu}}{(\text{hr})(\text{sq ft})(\text{F/ft})}$
L = length of heated surface, ft
$(P_2 - P_1)$ = pressure drop, lb/sq ft
t = temperature, deg F
T = temperature, deg F absolute
u = linear velocity, ft/hr
W = rate of fluid flow per tube, lb/hr
θ = temperature difference, deg F
μ = viscosity, lb/(hr)(ft)
ρ = density, lb/cu ft

Unless otherwise specified, the fluid properties should be taken at the average of the surface and fluid temperatures.

Temperature Difference

In many forced-convection problems the question of the correct or effective temperature difference involved in the heat-transfer coefficient is important. When a surface at a uniform temperature is swept by a fluid whose temperature is not appreciably changed by the heat transfer, θ is simply the difference between the surface and fluid temperatures. But in the case of a fluid flowing in a pipe, the fluid temperature may approach the tube temperature at a diminishing rate, as indicated by curve *a* of Fig. 1. For such cases the mean effective temperature difference is

$$\theta = \frac{\theta_1 - \theta_2}{\log_e \frac{\theta_1}{\theta_2}} = \frac{\theta_1 - \theta_2}{2.3 \log_{10} \frac{\theta_1}{\theta_2}} \quad \ldots\ldots\ldots\ldots [1]$$

where θ_1 and θ_2 are the initial and final temperature differences $(t_{s1} - t_1)$ and $(t_{s2} - t_2)$. This is known as the logarithmic mean temperature difference. It applies to the overall heat transfer between two fluids in parallel or counter flow, as well as to the individual surface effects, when the specific heats of the fluids and the local heat-transfer coefficients are sensibly constant throughout. The average coefficient for the entire surface is then equal to the local coefficient at any point.

When the conditions are as represented by curve *a*, the log mean, θ, will obviously depart very considerably from the arithmetical mean, θ', which is simply $(\theta_1 + \theta_2)/2$. However, if the fluid temperature varies as indicated by curve *b*, where the ratio of the initial and final temperature differences is not far from unity, the arithmetical mean may be used as a reasonably close approximation.

In a few applications, as in the case of fluids in viscous flow through pipes, the heat-transfer coefficient varies in some regular manner along the surface, so that the log mean temperature difference does not apply. In this case it is sometimes the practice to adopt some arbitrary temperature difference, such as the arithmetical mean, and plot the coefficients in such a way that the dimensions of the apparatus, as well as the fluid properties, are taken into account. Obviously the average coefficient is not comparable to the local or to the log mean coefficients obtained as above, unless the temperature difference is nearly constant or linear, as in curve *b* of Fig. 1.[22]

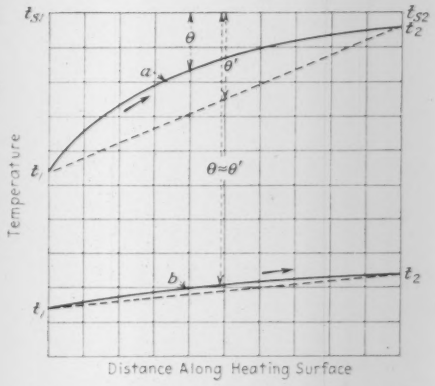

FIG. 1 COMPARISON OF LOGARITHMIC MEAN TEMPERATURE DIFFERENCE (θ) WITH ARITHMETICAL AVERAGE DIFFERENCE (θ') FOR TWO HEATING CONDITIONS

Fluid Flow

Since the frictional resistance and the mechanism of fluid flow bear an important relation to heat transfer by forced convection, a brief discussion of some of the fundamentals of this subject will be in order here.

In the case of fluids flowing through pipes, it has long been recognized that the type of flow, whether streamline or turbulent, depends upon the value of the Reynolds number, $R = \rho u d/\mu$. A number of observers have reported a fairly definite critical value for R of about 2300, with streamline flow below and turbulent flow above this point, although in general the critical region may extend over a considerable range.

The pressure drop for a fluid flowing through a pipe of length L and diameter d is given by the Fanning equation

$$P_2 - P_1 = \frac{2fL\rho u^2}{gd} \quad \ldots\ldots\ldots\ldots [2]$$

For clean, smooth pipes, under isothermal conditions, the friction factor, f, is a function of the Reynolds number only. In streamline flow, $f = 16/R$. In turbulent flow, f varies as R^n; the value of n changes continually from about -0.35 to -0.16 for higher values of R, but over a considerable range the function is approximately

$$f = 0.06R^{-0.2} = 0.06\left(\frac{\mu}{\rho u d}\right)^{0.2} \quad \ldots\ldots\ldots\ldots [3]$$

With increasing roughness of the pipe surface the friction factor becomes larger and the exponent n approaches zero, sometimes becoming positive for very rough surfaces.

The mechanical resistance to fluid flow is made up of two parts: surface (skin) friction, and the dissipation of energy in eddies. Heat transfer is directly related only to the skin-friction component, so that the success of formulas for calculating the heat transfer in terms of the fluid resistance depends upon

[22] For a more complete discussion of the temperature difference, see references 19(*c*) and (*f*).

the relative insignificance of the loss due to eddies. When the flow is confined in pipes and channels the eddies are usually small, so that the correspondence is fairly good. In general, the effect of turbulence is unpredictable; usually it increases the heat transfer, but in some cases the production of large eddies results mainly in higher resistance, particularly if the backwash interferes with the shearing action in the surface layer.

The effect of heat transfer upon fluid friction has been discussed by Keevil and McAdams[23] and Eagle and Ferguson.[24] When a viscous fluid, such as oil, is cooled or heated, the viscosity in the surface film becomes greater or less than that of the main stream. If the flow is streamline, the friction factor may vary by 100 per cent or more below or above the normal value for isothermal conditions. In turbulent flow this effect is much less pronounced, since μ has a smaller influence upon f (Equation [3]). In the case of a gas, the difference in the kinetic energy of the gas entering and leaving the tube should be taken into account, if the change in temperature is great.[25]

The flow of fluids over surfaces such as flat plates, aerofoils, and cylinders involves so many factors that an adequate discussion is not possible in the space available here. Some of the most significant recent contributions to this subject are included in the references given below.[26]

General Analyses of Forced-Convection Problems

1—streamline flow

Until recently the problem of heat transfer to fluids in streamline flow has received little attention because in most industrial applications the flow is turbulent. Within the past few years Drew,[27] Kraussold,[28] Kirkbride and McCabe,[29] Dittus,[30] and Sherwood, Kiley, and Mangsen,[31] have reported theoretical and experimental studies of heat transfer to viscous liquids in tubes. It has been shown that the purely theoretical formulas are not verified quantitatively by the experimental data. Further, no method has been developed for satisfactorily correlating the results obtained by all of these investigators. It is known that the heat transfer is affected by the length and diameter of the pipe, the specific heat and conductivity of the liquid, and the mass rate of flow, but the proper grouping of these variables apparently has not been found. The indications are that the effect of the temperature difference in producing viscosity gradients and in setting up free-convection currents should be taken into account in some way.

In Fig. 2 some of the most consistent data have been plotted in an attempt to provide a simple, tentative correlation for practical purposes. This includes tests on water, glycerol, and several kinds of oils, heated by steam, water, and electricity, with and without calming sections for smoothing out the flow before entering the heated section. The heat-transfer coefficient, h, is based upon the arithmetical mean temperature difference between the fluid and the tube wall. The logarithmic mean would not be expected to apply, since the temperature distributions in the oil and the local coefficients vary along the length of the pipe.

The equation of the line drawn through the points of Fig. 2 is

$$\frac{hd}{k} = 2.53\left(\frac{WC}{kL}\right)^{1/3} \qquad [4]$$

This should not be extrapolated beyond the limits indicated. Since

$$W = \frac{\pi}{4} d^2 u\rho$$

Equation [4] may be written in the form

$$h = 2.34\sqrt[3]{\frac{u\rho Ck^2}{dL}} \qquad [5]$$

which should apply approximately to the heating of any fluid in streamline flow. If the viscosity is not greatly affected by the temperature, these equations should apply also to the cooling of fluids, but in the case of oils a few data indicate that the coefficients average about 30 per cent lower when the oil is being cooled.

2—turbulent flow

(*a*) *Fluids in Pipes.* Colburn and Hougen[21] have given an excellent review of the development, by Prandtl, Taylor, Stanton, and others, of the Reynolds analogy between heat transfer and fluid friction. This leads to the equation

$$h = \frac{(f/2)C_p\rho u}{1 + \frac{u_s}{u_m}\left(\frac{\mu C_p}{k} - 1\right)} \qquad [6]$$

where u_s is the fluid velocity at the inner boundary of the surface film and u_m is the mean velocity over the cross-section. According to the Kármán-Prandtl theory,[10] the ratio u_s/u_m should be equal to $1.6(R/2)^{-1/8}$, although it has been found that Equation [6] agrees better with heat-transfer data if the value of this ratio is taken as about 0.35.

For gases, since $\mu C_p/k$ is constant and not far from unity,

$$h = (f/2)\,C_p\rho u \qquad [7]$$

Substituting the value of f from Equation [3]:

$$h = \frac{0.03\,C_p(\rho u)^{0.8}\mu^{0.2}}{d^{0.2}} \qquad [8]$$

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[23] C. S. Keevil and W. H. McAdams. *Chem. Met. Engg.*, vol. 36 (1929), p. 464.

[24] A. Eagle and R. M. Ferguson. "The Coefficients of Heat Transfer from Tube to Water," Proc. I.M.E., 1930, no. 4, p. 985; also issued as separate reprint by the I.M.E. (London).

[25] A. P. Colburn, T. H. Chilton and W. J. King. *Jl. Ind. Eng. Chem.*, vol. 23, August, 1931, p. 910.

[26] (*a*) J. W. Maccoll. "Research Work in Germany." *Aircraft Engg.*, vol. 2 (1930), p. 118.

(*b*) S. J. Davies and C. M. White. "A Review of Flow in Pipes and Channels." *Engineering*, vol. 128 (1929), p. 69, 98, 131.

(*c*) H. Geiger and K. Scheel. "Handbuch der Physik," vol. VII (Mechanik der Flüssigen und Gasförmigen Körper); J. Springer, Berlin, 1927.

(*d*) R. E. Wilson, W. H. McAdams, and M. Seltzer. "The Flow of Fluids Through Commercial Pipe Lines." *Jl. Ind. Eng. Chem.*, vol. 14 (1922), p. 105.

(*e*) W. H. McAdams. "The Flow of Liquids." *Refrig. Engg.*, vol. 11 (1925), p. 279.

(*f*) A. P. Kratz, H. J. Macintire, and R. E. Gould. "Flow of Liquids in Pipes of Circular and Annular Cross-Sections." Univ. of Ill. Eng. Exper. Sta. Bull. No. 222, 1931.

(*g*) C. B. Millikan. "The Boundary Layer and Skin Friction for a Figure of Revolution." Trans. A.S.M.E. (1932), APM-54-3.

See also footnotes nos. 18, 19 (*c*), and 19 (*g*).

[27] T. B. Drew. *Jl. Ind. Eng. Chem.*, vol. 24, Feb., 1932, p. 152. See also ref. 19 (*e*) and 19 (*f*).

[28] H. Kraussold. *V.D.I. Forschungsheft*, 351 (1931); see also: *Forschung*, vol. 3 (1932), no. 1, p. 21.

[29] C. G. Kirkbride and W. L. McCabe. *Jl. Ind. Eng. Chem.*, vol. 23 (1931), p. 625, 1180.

[30] F. W. Dittus. Univ. of Calif. Engg. Bull., vol. 2, no. 11, 1929.

[31] T. K. Sherwood, D. D. Kiley, and G. E. Mangsen. *Jl. Ind. Eng. Chem.*, vol. 24, March, 1932, p. 273.

which agrees well with the average of the experimental results collected by Fishenden and Saunders.[32]

The original Nusselt equation, derived by the principle of similitude or dimensional analysis, has been used by several investigators for correlating the data for gases and liquid in the form

$$\frac{hd}{k} = C_1 \left(\frac{\rho u d}{\mu}\right)^m \left(\frac{\mu C_p}{k}\right)^n \quad \ldots\ldots\ldots\ldots [9]$$

Fairly good agreement has been obtained with various values of the exponents, ranging from 0.7 to 0.833 for m, and from 0.33 to 0.5 for n. A compromise which seems to bring the data for liquids better into line with those for gases is given by Cox[33] as

$$\frac{hd}{k} = 0.0192 \left(\frac{\rho u d}{\mu}\right)^{5/6} \left(\frac{\mu C_p}{k}\right)^{1/3} \quad \ldots\ldots [10]$$

when converted to consistent units.

(b) Fluids Flowing Across Wires and Cylinders. Most of the experimental work on this problem has been concerned with the transfer of heat to or from air flowing perpendicularly across wires and pipes. Some of the data are correlated in Fig. 3. Just as this was completed a recent paper by Ulsamer[34] appeared, which contains

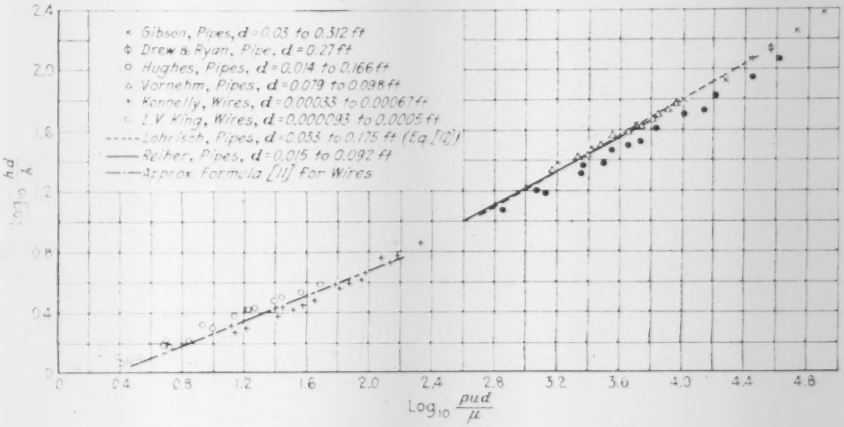
Gibson, Pipes, d = 0.03 to 0.312 ft
Drew & Ryan, Pipe, d = 0.27 ft
Hughes, Pipes, d = 0.014 to 0.166 ft
Vornehm, Pipes, d = 0.079 to 0.098 ft
Kennelly, Wires, d = 0.00033 to 0.00067 ft
L.V. King, Wires, d = 0.000093 to 0.0005 ft
Lohrisch, Pipes, d = 0.033 to 0.175 ft (Eq. [12])
Reiher, Pipes, d = 0.015 to 0.092 ft
Approx. Formula [11] for Wires
hd/k
Log10 ρud/μ

FIG. 3 CORRELATION OF DATA FOR AIR FLOWING ACROSS A SINGLE WIRE OR PIPE

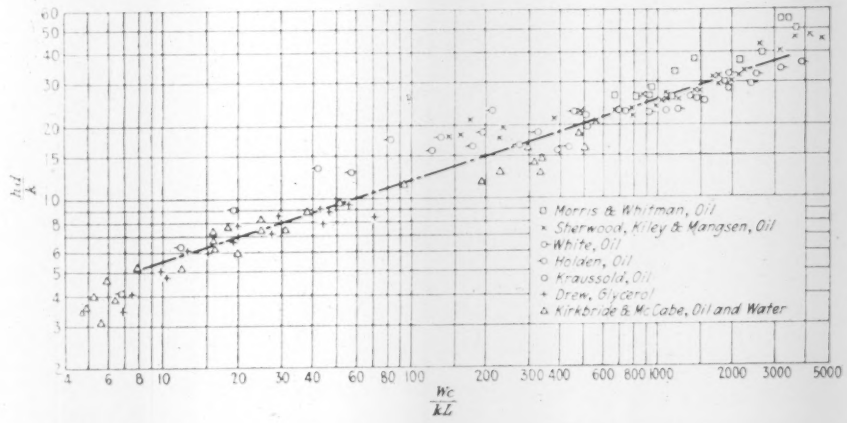

FIG. 2 CORRELATION OF HEATING DATA FOR LIQUIDS IN STREAMLINE FLOW IN PIPES

an almost identical plot and some new data by Vornehm.

The equation of the broken line drawn through the points for wires, in the lower part of Fig. 3, is

$$\frac{hd}{k} = 0.764 \left(\frac{\rho u d}{\mu}\right)^{0.41} \quad \ldots\ldots [11]$$

From tests on the diffusion of vapors, Lohrisch[35] has derived an equation for the heat-transfer coefficient which is represented by the dotted line of Fig. 3:

$$\frac{hd}{k} = 0.282 \left(\frac{\rho u d}{\mu}\right)^{0.585} \quad \ldots\ldots [12]$$

This seems to be about the best approximation for single rods or pipes in the range of Reynolds numbers between 300 and 40,000. The indications are that the exponent continually increases with the Reynolds number, but these formulas should apply for all practical purposes, with any gas. Although very few data are available for liquids, Ulsamer has shown that Davis' results for wires in water and oils may be brought into line with the graphs of Fig. 3 if hd/k is divided by $(\mu C/k)^{0.31}$.

The foregoing discussion refers to ordinary smooth surfaces in normal (undisturbed) flow. Roughening the surface or increasing the turbulence raises the heat-transfer rate. However, the ratio of heat transfer to fluid friction is considerably improved if the surfaces are streamlined.

(c) Plane Surfaces. Practically all of the published work on plane surfaces has been limited to air as the cooling fluid. References to some of the literature of this subject are given by Taylor and Rehbock[36] in connection with their study of heat transfer from plane and finned metal surfaces. Significant contributions have also been made by Eliás[37] and Rowley.[38] The various data for *smooth* surfaces and parallel flow are represented quite well by the formula

$$\frac{hL}{k} = 0.055 \left(\frac{\rho u L}{\mu}\right)^{0.75} \quad \ldots\ldots [13]$$

This formula is suggested mainly by the theory of dimensions, and cannot be regarded as definitely established, since it is based on tests in which only the velocity (u) was varied over a wide range. In all cases the order of magnitude of L was about one foot, and the fluid properties were close to those of atmospheric air. However, in the absence of specific data, formula [13] may be used to predict the heat transfer from a smooth plane surface in any gas over a considerable range of the variables.

[32] M. Fishenden and O. A. Saunders. *Engineering*, Aug. 8, 1930, p. 177.

[33] E. R. Cox. Trans. A.S.M.E. (1928), PET-50-2.

[34] J. Ulsamer. *Forschung*, vol. 3 (1932), no. 2, p. 94.

[35] W. Lohrisch. *V.D.I. Forschungsheft*, 322 (1929), p. 46.

[36] C. F. Taylor and A. Rehbock. Nat. Advis. Comm. for Aeron., Tech. Note No. 331 (1930).

[37] F. Éliás. *Zeit. für angew. Math. u. Mech.*, vol. 9 (1929), p. 453; also: N.A.C.A. Tech. Memo. No. 614 (1931).

[38] F. B. Rowley, et al. *Heat. Piping and Air Cond.* (Jour. Sect.), vol. 2, p. 501, June, 1930, and vol. 3, Oct., 1931, p. 870.

For rough surfaces the coefficients are increased by something like 10 to 40 per cent, and the exponent of the Reynolds number approaches unity. Rowley found that the coefficients were somewhat reduced if the air stream struck the surface at an angle.

SPECIFIC FORCED-CONVECTION DATA AND FORMULAS

1—STREAMLINE FLOW

For the common hydrocarbon oils the product ρCk^2 is so nearly constant that for practical purposes Equation [5] may be reduced to the form

$$h = 43 \sqrt[3]{\frac{v}{DL}} \text{ Btu/hr/sq ft/F} \quad \ldots\ldots [14]$$

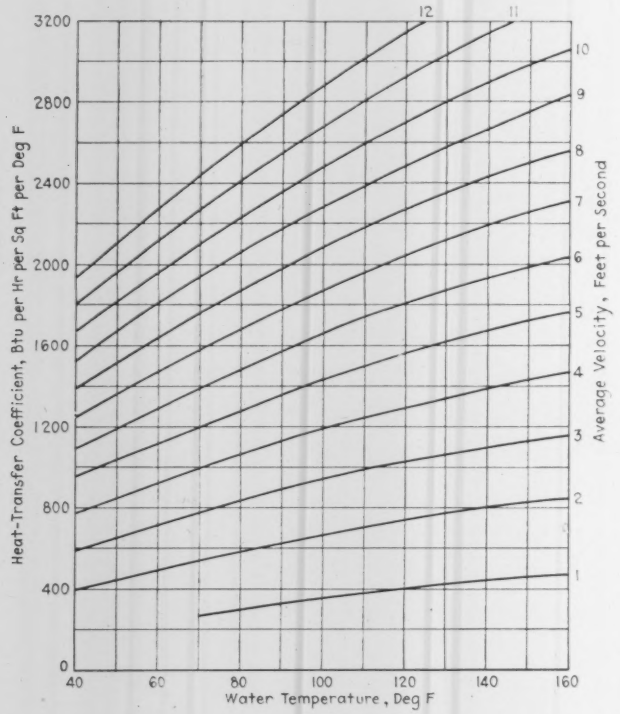

FIG. 4 HEAT-TRANSFER COEFFICIENTS FOR WATER FLOWING IN A $^3/_4$-IN. I.D. TUBE
(From Eagle and Ferguson's tests.)

if v = oil velocity, ft/sec
D = tube diameter in inches, and
L = tube length, in feet

This applies only to the heating of oils in viscous flow in tubes, using the arithemetical average temperature difference. In a 0.7-in. I.D. tube 10 ft long this gives for v = 0.1, 1 and 4 ft/sec, h = 10.3, 22.5, and 35.7, respectively. If the oil is cooled, h will be roughly 30 per cent lower.

2—TURBULENT FLOW

(*a*) *Water in Pipes.* Two valuable papers on this subject have been published recently; one by Eagle and Ferguson[24] and the other by Lawrence and Sherwood.[39] Some of Eagle and Ferguson's results are reproduced in Fig. 4, which gives the local heat-transfer coefficient at various water velocities and temperatures, in a $^3/_4$-in. I.D. pipe. Lawrence and Sherwood investigated the effect of tube length upon the average coefficient for a tube of the same size in four lengths ranging from 2.91 to 11.09 ft. Their results for all four lengths agree fairly well with the data of Fig. 4, indicating a negligible effect of tube length in this range. From a study of these and other data it appears that the coefficient for water in turbulent flow in clean pipes may be obtained, with reasonable accuracy, from the formula

$$h = \frac{1.8(t + 100)v^{0.8}}{D^{0.2}} \text{ Btu/hr/sq ft/F} \quad \ldots\ldots [15]$$

if t is the average water temperature in deg F, v the velocity in ft/sec, and D the pipe diameter in inches. There are indications that for very short pipes the coefficient will be somewhat higher, and of course the presence of scale or dirt in the pipe may reduce the value of h considerably.

(*b*) *Oils in Pipes.* Morris and Whitman[40] have correlated the results of their extensive tests, on the heating and cooling of several different oils flowing through a pipe, by means of a graph of the Nusselt type (Eq. [9]). They found that the exponent m of the velocity term varied from a little more than unity to about 0.8 at higher Reynolds numbers. Their coefficients are somewhat higher than those of Sherwood, Kiley, and Mangsen,[31] and a few other scattered data. Most of the heating data can be represented almost within the experimental accuracy by means of the formula

$$h = 70 \frac{u}{Z^{0.63}} \text{ Btu/hr/sq ft/F} \quad \ldots\ldots [16]$$

where u is the oil velocity in ft/sec and Z is the viscosity in centipoises at the average of the inlet and outlet temperatures. If the oil is being cooled, the coefficient will be about 25 per cent lower. If the viscosity varies over a wide range between the temperature limits, the average value of Z should be obtained more accurately by integration.

(*c*) *Liquid Heat Exchangers.* When a viscous liquid is made to flow across a bundle of tubes the coefficients are usually much higher than for parallel flow, due to the mixing action, although the exponent of the velocity term becomes considerably less than unity. The actual overall coefficients vary so widely with the design and with the conditions on both sides of the tube wall that no specific data can be given here. Tests on several types of commercial heat exchangers are reported by Heinrich and Stückle[41] and by Short and Heller.[42]

(*d*) *Gases in Pipes.* Walker, Lewis, and McAdams[19(c)] have given a formula which should apply to any of the common industrial gases having thermal properties similar to those of illuminating gas, air, and carbon dioxide:

$$h = 0.22 C_p T_f^{.2} G^{0.8}/D^{0.2} \text{Btu/hr/sq ft/F} \quad \ldots\ldots [17]$$

in which C_p is the specific heat at constant pressure, T_f the mean film temperature (average of gas and wall) in deg F absolute, G the mass velocity in lb per sq ft of cross-section per sec ($\rho \times v$), and D is the pipe diameter in inches.

An approximate formula for air, N_2, O_2, and CO at ordinary

(*Continued on page 426*)

[39] A. E. Lawrence and T. K. Sherwood. *Jl. Ind. Eng. Chem.*, vol. 23, March, 1931, p. 301.

[40] F. H. Morris and W. G. Whitman. *Jl. Ind. Eng. Chem.*, vol. 20 (1928), p. 234.

[41] E. Heinrich and E. Stückle. *V.D.I. Forschungsheft*, 271, 1925. See also: B. N. Broido, Trans. A.S.M.E., vol. 48 (1926), p. 1337.

[42] B. E. Short and M. M. Heller. Univ. of Texas Bull. No. 3128, 1931.

The Balancing of

ECONOMIC FORCES[1]

Suggested Lines of Attack on the Interrelated Problems of Consumption, Production, and Distribution

THE American Engineering Council in January, 1931, authorized the appointment of this Committee on the Relation of Consumption, Production, and Distribution. When appointed, the Committee was assigned the task of studying a series of suggested points of attack relating to the balancing of economic forces. These suggested points of attack were:

1 Maintaining or increasing the consumption of goods and services
2 Balancing of plant, machinery, and processes against production demands
3 Balancing of distribution agencies against consumer requirements
4 Balancing of man power against production and distribution demands
5 Controlling of money and credit to satisfy the needs of government, business, and individuals
6 Encouragement of research activity—to increase human well-being through development and progress in industry and business
7 Balancing of public works against public needs.

To this list has been added one other, which is involved in all of the others, and is of such importance as to demand particular study:

8 Balancing of agricultural supply with effective demands.

GENERAL OBJECTIVE AND METHOD OF ATTACK

Economic balance obviously can be attained at widely different levels of the general standard of living. However the Committee has interpreted its commission as being—

> the selection and recommendation of such governmental, financial, and business policies as will maintain in the United States a standard of living that is high, broadly distributed, and free from severe fluctuations.

Being acquainted with the control of the forces and the utilization of the materials of nature for the benefit of man through the instrumentality of modern technology, and realizing that this method is likewise applicable to the control of many economic forces, the Committee believes that—

> the objective stated is physically possible for the whole of Western civilization.

This statement is contrary to the assumption revealed in much present-day speaking, writing, and thinking on economic matters.

Furthermore, in view of the natural resources, the technological development, the limited degree of dependence on foreign countries for raw materials, and other important factors which characterize the United States, the Committee believes that—

> in a very large degree the desired economic readjustment can be realized in the United States, even though it may be impracticable to accomplish such a purpose throughout the Western world.

This thought is contrary to a large body of opinion which questions the ability of the United States to rise above world conditions.

In studying the problems outlined the Committee has not confined itself to engineering viewpoints, nor to engineering solutions. The Committee endeavored to look at all questions objectively and in their broadest aspects. It will be observed that there are many similarities between engineering and economic principles. These are accepted as evidence of a vital relationship between the two sciences.

EXPLANATIONS OF THE PRESENT ECONOMIC SITUATION INADEQUATE

The Committee set itself the task of endeavoring to find adequate explanations for the present economic situation. It realized that unless a working hypothesis was established it would not be possible to suggest corrective measures with any assurance of validity, nor to visualize the effect on each other of apparently useful recommendations nor to evaluate their effect on the entire economic situation.

The Committee finds the following popular explanations of the present economic situation to be questionable and/or inadequate:

Technological Unemployment
Wasteful Manufacture and Distribution
General Overproduction

[1] Progress report made February 5, 1932, to the American Engineering Council by its Committee on the Relation of Consumption, Production, and Distribution. Comment on this report is solicited, and should be addressed to L. W. Wallace, Executive Secretary, American Engineering Council, 744 Jackson Place, Washington, D. C.

Speculation
Instalment Buying
Breakdown of International Trade and Credit.

Technological Unemployment is the term commonly applied to the displacing of labor by the improvement of machinery, processes, and organization. It has been assumed by some that a catastrophic cumulation of unbalance from this cause is responsible for the present recession in business. There is no evidence available to prove this. The Census of Manufactures of the Department of Commerce indicates that there was, on the whole, a slow but perceptible increase in the percentage of the total population gainfully employed up to the business recession in 1929.

Prof. Paul H. Douglas[2] gives more evidence to the same effect, and presents an economic analysis which supports the same conclusions. There is no evidence that at the time of the stock-market break in 1929 there was an unusual volume of unemployment from technological improvements. The evidence is to the contrary.

This statement is not intended to minimize the seriousness of the problems which arise from technological advance. At times the effect of progress does fall with crushing force upon individuals, business firms, entire industries, and whole communities. It must be remembered that technological developments have been going on for centuries. Also that the normal method of adjusting the volume of production to a general increase in the efficiency of production has been a progressive shortening of working hours.

Wasteful Manufacture and Distribution, while of serious proportions, cannot be assigned as the primary cause of the existing unbalanced economic condition. In fact, a plausible case may be made for the growing wastefulness in distribution, in that it has absorbed some workers displaced by improved methods of manufacture. Doubtless the inefficiency in distribution has mitigated the severity of the problem of technological unemployment. Elimination of waste in both manufacture and distribution should be aggressively pursued because of its direct influence upon raising the standard of living and increasing leisure. Notwithstanding the foregoing, there appears to be no element in the elimination of waste in manufacturing and distribution which could be used as a direct means for controlling the business cycle.

General Overproduction is a commonly assigned primary cause for the business depression. In this point of view the Committee cannot concur. There may have been overproduction in specific industries, particularly those manufacturing products of comparatively inelastic demand, in certain industries which are affected by fashion or other external influences, and in others dependent upon certain natural resources, such as petroleum and soft coal. The individual readjustments required are often violent and even destructive. But the necessity for such readjustments has never been absent in good or in bad times. There is no evidence that their effects have been cumulative at this time.

[2] "The Problem of Unemployment," Douglas and Director.

In view of the large increase in consumption physically possible in this country, the probability of having approached a condition of *general* overproduction is indeed remote. There are millions of families whose power to consume is lowered by faulty economic conditions. In the opening up of the dormant markets they represent lies the greatest hope of American industry. The real difficulty is due to the lack of a proper balance between production, purchasing power, and consumption, and not to overproduction.

Speculation. The inordinate speculation which preceded the collapse of the boom in 1929 was undoubtedly an aggravating element in the economic situation. This phenomenon and its opposite, the unreasoning panic which followed, are psychological factors of real effectiveness; but it is doubtful if they are primary causes of the business depression. They undoubtedly exaggerate and extend conditions of unbalance.

The time-honored assumption that the open market is a steadying influence on prices is evidently a myth. This is at least true in so far as the security market is concerned during periods of expansion. If the open market is to justify its existence upon the ground that it has a steadying influence on prices, it will have to accomplish such internal reforms as shall bring its performance in line with this assumed purpose. Investment bankers and the speculating public have definite responsibilities in the matter.

Instalment Buying was so rapidly expanded in the months preceding the collapse that one might naturally look to this development for a satisfactory explanation of the present economic situation. However, instalment buying does not appear to be a primary cause. It undoubtedly prolonged the unstable balance of the boom, and has hindered the processes of recovery.

The wide extension of consumer credit masked the primary fact of the boom, which was the failure of purchasing power to keep in step with production. In the situation thus created the normal effect of slackening demand was delayed, and the unstable balance was perpetuated. The processes of recovery have been hindered by the necessity for applying new earnings to the payment of goods already in use, instead of using them to move goods of current manufacture. There are, nevertheless, unrealized possibilities of usefulness in the extension of consumer credit, provided it is done in an appropriate degree at the proper time of the business cycle.

The Breakdown of International Trade and Credit is frequently given as a primary cause for the present economic condition in the United States. There is no doubt that the demoralized economic condition in Europe, due to the World War, has had a pronounced influence upon the economic condition of this country. This is a serious situation. There is a growing feeling that the financial and industrial operations of this country have been tied too closely and in too complicated a manner to foreign operations. It is also felt that this situation has not been of any lasting benefit to either this country or other countries.

The breakdown of international trade and credit may properly be considered a disturbing element, but it need not be an insuperable barrier to recovery in this country in view of our wealth, natural resources, and technical ability, and the small degree of necessary dependence on foreign commerce.

The present economic situation is complex. The lines of action necessary for correction may be expected to be of the same nature. There is no single action which will be effective over the entire area of the maladjustment. Such simplification as is possible will result from keeping clearly in mind the ultimate objective: a standard of living for the United States that is high, broadly distributed, and free from severe fluctuations.

It is clear that the arbitrary control of modern industry and commerce, in all their ramifications, complexities, and details, is beyond the power of human beings. The influences now at work must continue to govern its details. In particular, the profit motive and the active force of competition must be retained in such effective operation as will give society the benefit of the continuous improvement in methods and lowering of costs which they are capable of giving. They must be restrained in their destructive and unsocial manifestations.

The problem of the relation of consumption, production, and distribution is one of supreme importance. More and more will it command the attention and devotion of the most intelligent, unselfish, and far-seeing men and women of the body politic. There is no human problem which compares with it in difficulty, in magnitude, in hopefulness. It is world-wide in its import and study. What is being contemplated is nothing less than a purposeful changing of the course of history. To such an undertaking the highest human capacities of our time must inevitably devote themselves.

APPARENT CAUSES OF THE PRESENT BUSINESS DEPRESSION

The typical business cycle is a complex phenomenon involving elements presented in all of the preceding explanations and others. It may be analyzed from several different points of view—monetary, psychological, industrial, and others. Any one of these approaches will give useful information, but none will yield a completely satisfactory explanation. Probably the most satisfactory understanding of the cycle lies in a study of the lack of balance between production and purchasing power.

The depression which began in 1929 seems to be the recession phase of a typical business cycle occurring coincidently with a typical post-war deflation, and aggravated by a unique agricultural distress and a slackening of the opportunities for investment at a profit. The foregoing explanation is a sound statement of the cause of the present depression because it comprehends a large area of observed phenomena.

The Typical Business Cycle is characterized by a failure of purchasing power to keep in balance with production.

A classical economic theory asserts that purchasing power normally keeps in balance with production, being in its nature complementary thereto and consequent upon it. Under an ideal condition where business enterprise is neither expanding nor contracting, but is regularly paying out all it receives—and under which condition all individuals, governments, and the like do the same thing—the theory holds. In this ideal state a manufacturing firm making and selling $100,000 worth of goods per month would pay out the same total amount per month for materials, wages, salaries, services, interest, dividends, taxes, maintenance, replacement of worn equipment, and the like; and every individual and organization to which a payment was made would likewise disburse the sum received. Thus the entire $100,000 remains in the general pool of purchasing power. Under these circumstances goods produced are purchased by the earnings of the processes of production.

Two well-known authorities, Foster and Catchings,[3] call attention to the fact that this is not the normal course of business, because both individuals and business enterprises find it necessary to lay by funds for future use. This act of saving, for a time at least, withdraws funds from purchasing power and thus makes it impossible for society as a whole to buy all the goods produced. Savings are necessary, however, although they tend on the whole to prevent the purchase of all the goods produced. This is their celebrated "paradox of thrift."

Foster and Catchings recognize the further fact that money and credit are elastic quantities. They would, under some conditions, expand them to make up for the amount withdrawn for savings.

A well-known English economist, J. Maynard Keynes,[4] resolves the paradox. He shows that the normal way in which savings are returned to purchasing power is through the act of investment. By investment is meant new investment. What most distinctly is not meant is that *A* should buy old stock certificates from *B*, in which case the stock shifts from *B* to *A* and the money from *A* to *B*. Under this condition the problem of getting this money to buy goods still remains. If, on the other hand, the savings or moneys are used in investments in new buildings, factories, homes, utilities, and other new wealth-producing activities, purchasing power is increased, and hence a tendency to maintain a balance between production and purchasing power is established.

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[3] See their books, "Money" and "Profits," also their numerous articles in the *Atlantic Monthly* and elsewhere.

[4] See particularly his voluminous, brilliant, and difficult book on "Money," from which the common-sense thesis here presented is abstracted.

As an example, it is probable that the general purchasing power of the country was maintained during the comparatively prosperous years from 1922 to 1926 by the rapid flow of millions of dollars of savings into the expanding automobile and other industries. Savings were not held out of purchasing power to any appreciable extent during that period, and thus purchasing power kept step with production.

Another Englishman, J. A. Hobson,[5] suggests one reason why from time to time the rate of savings exceeds the rate of investment, thus (on the Keynes theory) initiating a decline in business. His statements are modified slightly in this presentation to bring them in line with Keynes. According to Hobson, when too small an amount of the disbursement of wealth goes to those who earn wages and small salaries and too large an amount is paid those who earn large salaries and receive dividends, there are likely to accrue savings which cannot be profitably invested. The reason for this view is that money paid to wage earners and low-salaried employees is usually spent. Their needs are so insistent that only a small amount can be saved. Therefore any increase in disbursements to these classes is likely to broaden the market for goods.[6] If, instead, largely increased payments are made to those who normally spend little and save much, it may well be that, with no corresponding broadening of the wage-earners' purchases, these savings will find no profitable investment, and will thus be lost to purchasing power. In such a case the rate of saving exceeds the rate of investment, and hence a business decline is initiated. This general theory basically looks upon uninvested savings, of which there are hundreds of millions idle in the banks of this country, as equivalent to unbought or at least unpaid-for goods. There is, of course, no perfect equality, for the money side is an elastic quantity, and goods deteriorate, become outmoded, or are discarded for other reasons.

In the meantime the distribution of profits not supported by actual increased purchasing power gives an illusion of permanent prosperity. As a consequence, stocks rise, money flows into the stock market in preference to seeking lower returns from investment, and the uncontrolled and inevitably disastrous boom is on.

Keynes's full statement is that when the rate of investment exceeds the rate of saving, business improves and prices rise; when the rate of saving exceeds the rate of investment, business recedes and prices fall. This presentation would have to be modified somewhat to apply to American conditions. An appreciable share of the money seeking investment in this country comes from the workers, whose savings accumulate in postal savings, in savings banks, and in the insurance companies. The aggregate volume of the accumulations of workers is large. It cannot be assumed that all money paid to American labor will go immediately into purchasing power.

The grim processes of normal recovery from a depression have been described by Virgil Jordan[7] as consisting of the gradual exhaustion of uninvested savings, the writing off of bad debts, and the borrowing of money on life insurance to sustain existence. Other large-scale operations of the same character and effect take place. When these painful processes of readjustment have proceeded so far that the purchasing power of the market exceeds current production and a lack of goods is indubitable, recovery commences.

Such appears to be, in its simplest terms, the nature of the typical business cycle, which is in part responsible for the current economic distress.

A Post-War Deflation of "secular" or long-term duration is the second element in the present business depression.

It is not the least of the miseries and injustices of war that no means has been discovered for financing such a struggle that does not involve inflation and the arbitrary and unsound expansion of the amount of money in use, all of which is reflected in a rise in the general price level. During a period of inflation there is an immense stimulation of business. This stimulation is often supplemented by efforts such as were directed toward the farmers, urging them to meet the pressing food demands of the World War. Inflation is normally followed by a compensating deflation after a war ends. The deflation may be sharp or gradual, controlled or uncontrolled. This country is now experiencing the effects of the World War deflation.

Deflations of the same type have occurred twice before in this country. From 1820 to 1850 there was a long-continued decline in the price level—in other words, a long-continued deflation. This period was characterized by severe financial distress, three or four cycles of depression, bank failures, and political unrest. The discovery of gold in California in 1849 started a gold inflation which, it is claimed, checked the long-continued decline. This deflation was followed by a period of recovery which lasted until the Civil War.

The second similar decline was that following the mid-century wars of Europe and the United States. The price decline lasted roughly from 1870 to 1895. This period in the United States was also characterized by labor troubles, agricultural and political unrest, greenback difficulties, and a general slowing down of business. It was in part alleviated in this country by the expansion of the western frontiers, by the development of natural resources, and by new inventions. This period was terminated by the discovery of gold in Australia, Alaska, and South Africa, and the invention of the cyanide process of gold extraction.

The world is now experiencing a secular price decline due to similar causes. In the two previous periods of a

[5] See especially his book "Rationalization and Unemployment."

[6] This is the American theory that good business requires high wages. The crash that occurred in 1929 did not disprove this; it reemphasized the principle.

[7] See his paper "Economic Aspects of Stabilization," read before THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS on December 2, 1931, and published in the January, 1932, issue of MECHANICAL ENGINEERING, p. 23.

secular decline in the price level, each of the declines was arrested by new gold discoveries. The seriousness of the present situation is deepened by the fact that mining engineers feel very doubtful of any new large-scale additions to the gold supply which would start a typical gold inflation; and meanwhile the old mine workings are becoming yearly less productive. The prospect is serious. Society does not prosper under a long-continued deflation.

The Agricultural Crisis. A post-war deflation has always borne most quickly and most heavily on agriculture. But in the United States, agriculture is now burdened with new ills, particularly with regard to the great staples wheat and cotton.

Wheat is not only feeling the impact of the expansion of new territories, in Canada and Russia, but also that of new varieties and processes. The new processes, largely mechanical, result in a great increase in both acreage and production per acre. They also make possible a satisfactory extension of the industry into more arid regions than had before been thought possible. Modern methods are also penetrating areas like Russia.

The same extension of areas applies to cotton raising. In foreign countries there are the new plantings in Egypt, the Sudan, and Turkestan; and in the United States the new cotton fields of northwestern Texas, where climatic and other conditions have led to new and more economical methods of production. This increase in production has met a decrease in demand due to the introduction of rayon and changes of fashion in women's apparel.

This is commonplace process, but none the less distressful. It is one of the elements responsible for the present economic situation in this country.

Slackening of the Opportunities for Profitable Investment. Is it not possible that this country is sufficiently equipped with railways, steamships, factories, and mines to meet all of its reasonable needs for some years to come? There is of course much work to be done and many improvements to be made, but is not the initial task of equipping a mechanized society past the stage of rapid growth? Will not therefore the demand for investment consequently decrease in the years ahead for reasons quite aside from any possible overproduction? Such appears to be the thought of Horace B. Drury as expressed in a recent paper, "The Hazard of Business."[8]

It is easy to become unduly and prematurely alarmed in this matter. But such a possibility is in the minds of many engineers. It is unlikely that the past rate of acceleration of investment in mechanical equipment can continue indefinitely. If the opportunities for new investment should decrease appreciably, prosperity on the Keynes formula would become more difficult. A countervailing factor is that one of the results would be a permanent lowering of the interest rate, which in turn would broaden the field for profitable investment.

The foregoing analysis seems to cover the nature of the outstanding elements of the present situation. As already stated, the opinions expressed are not fixedly held. They are subject to review and change. But working hypotheses must be formed if hopeful remedies are to be sought. It is for the purpose of suggesting effective action that this investigation of causes was undertaken.

[8] Read before the Taylor Society, December 4, 1931.

SUGGESTED LINES OF ACTION

The present economic situation is complex. The lines of action necessary for correction may be expected to be of the same nature. There is no single action which will be effective over the entire area of the maladjustment. Such simplification as is possible will result from keeping clearly in mind the ultimate objective:

> a standard of living for the United States that is high, broadly distributed, and free from severe fluctuations.

If one could take a position sufficiently far above the surface of the earth and were possessed of sufficient keenness of vision to see from that point what is going on in the United States as a whole, he would observe rivulets of materials leading from farm, forest, mine, and ocean, and gathering into broad streams in their flow toward industrial establishments. Thence he would see the finished goods flowing in smaller streams to wholesalers, then in still smaller streams to retailers, and lastly and finally as subdivided particles reaching ultimate consumers. There would be, if it were visible, a similar but reverse flow of money and credit in its various forms. The larger transactions would involve the transfer of large amounts, the smaller ones, of small amounts, while the smallest would require only the change carried in the individual's pocket. The enormous extent of these operations, their unimaginable variety, the incalculable complexity of the courses they take, the innumerable final objectives they reach and serve, are beyond human comprehension or calculation.

The guiding principle which now preserves order in this complicated situation is the profit motive. It has become fashionable to argue that this force tends to become ineffective and may soon be discarded. It may properly be said that it is only one of many motives by which men are moved, and that it is often overshadowed by other elements more clearly in the foreground of consciousness. The real function of profit goes deeper than motive. In our economy it is a fundamental requirement for continued existence, and is never long neglected without vital peril. No psychological tests or analysis reveal this fact; it is a solidly established commonplace of business experience. It is the ruling condition which, when effectively met, permits the superposition of many other less impersonal motives. Its useful function is in providing a firm foundation for more spiritual structures.

The nature of remedial activities must be such that they do not require a beyond-human knowledge nor a beyond-human skill in planning to become measurably effective. They must also, on the whole, take human nature as it is found, employing its forces and desires and giving direction instead of applying compulsion.

These considerations seem to rule out most of the "five-year," "ten-year," and "twenty-year" plans which have been recently presented.

Two recent attempts have been made to bring this incomprehensible mass of economic transactions under control. The first was made by the United States War Industries Board during the World War. This task was simplified by the fact that there was but one customer—the United States; one objective—the winning of the war; and unlimited resources—that is, the artificial extending of credit which goes with war inflation. In contrast with such a comparatively simple set of conditions, these facts now and normally prevail in the United States: One hundred and twenty million customers, each having many objectives, these objectives embracing plans for enriching the existence, satisfaction, and desires of each customer; and each customer having limited resources. The mechanism which served the earlier occasion will not serve this one.

The other attempt at complete economic planning is that going on in Russia. This effort has also been simplified. It is based upon an alleged temporary low standard of living, a standard of living with a limited number of necessities and a still more limited number of luxuries. The adoption of such a formula in the United States would mean the reduction of the richness and variety of the comforts and satisfactions of the American people.

The American people have established a going mechanism of money, credit, labor, and services which operates to direct the flow of that complex of goods which the aerial observer saw. The mechanism is not operating properly. However, in view of the complexity of the processes and the degree of success with which it has operated, the decision must surely be to study its deficiencies, improve its organization, and lubricate its movements, rather than to discard it forthwith. This being the necessary and logical decision, it would be wise to start the study by looking first at governmental and general financial policies which affect large operations and large sums of money, rather than by attempting to develop means for arbitrarily controlling the flow of separate commodities. In fact, the immediate problem is to answer the question: How can the rate of saving and the rate of investment be balanced?

Taxation may be used to secure the desired balance. By increasing taxes during one phase of the business cycle, excess savings may be decreased, and by floating Government bonds at another phase an opportunity may be provided for investing savings. One means by which this can be accomplished is by establishing the principle of long-time governmental budgeting.

Long-Time Budgeting is recognized as essential to first-class business management. It is one of the new mechanisms of management which has resulted from a union of engineering and financial principles. It is not in accordance with the principles of good management for the Government to attempt to balance its income and expenditure in each fiscal year. The Government should recognize that in the course of a business cycle there is a time to tax and a time to relieve taxation. There is a time to borrow and a time to repay borrowing. There is a time to expand money and a time to contract it. There is a time to extend operations for public works and a time to contract them.

It would appear that if, when employment has reached a certain low point, a policy were followed of borrowing for extending public works, this action would have a quick remedial effect on the business situation. Such governmental borrowing would serve to reduce the accumulation of savings seeking investment by drawing them into Government activities. It would, furthermore, have the direct effect of furnishing work in increased quantity to a body of workmen in which unemployment would otherwise be growing.

The time for taxation is when business is good and profits are being made. Taxation then, if taken from profits, has the effect of reducing the amount of funds seeking investment and flowing into speculative channels. The concurrent repayment of the sums borrowed in the earlier period of the cycle tends on the whole to contract currency and thus acts as a brake on that upward movement of prices which is one of the factors building up the speculative structure of a boom.

Furthermore it does not appear desirable to lay aside reserves in prosperous times to spend on public works in dull times. Such an accumulation of funds would be embarrassing to the necessary balance between savings and investment. In large-scale governmental operations it is preferable, contrary to the accepted principles of financial morality, to borrow, spend, and repay rather than to save and spend.

To recapitulate, borrowing, public works, taxation, and retirement of borrowing applied at such times, in such degrees, and in such ways as shall be found by experience to be useful, will have remedial effects on the business cycle itself. Thus, dangerous accumulations of idle funds (which, as has been said, imply unsold goods) will be put to work; credit will be extended by the borrowing operations, thus tending to raise prices at a time when they are otherwise in danger of a disastrous lowering; and work will be furnished—all three at a time when they are most needed. On the other hand, the slowing up of public works, increased taxation, and the payment of loans will release men required for extending industry, prevent dangerous accumulations of money which can find no profitable use, and restrain a hysterical rise in the price level, with all the train of disasters which follow therefrom, at a time when most needed.

These policies are not capable of immediate application, and hence cannot be used in the present situation. The period of borrowing on most favorable terms has passed, the needed governmental reorganizations of public-works control has not been effected, and the study needed to coordinate the program has not been given. The possibilities outlined will not become fully available except as they are worked out in preparation for the next turn of the business cycle.

The Public Works contemplated in this connection must

be of kinds that are non-competitive with private business. This statement is not based on any theory of the rightness or wrongness of government ownership of public utilities, or of the desirability or undesirability of the Government's "going into business." The reason is a much simpler and more direct one. The work undertaken by the Government must be *in addition* to any other work that might be undertaken. If the Government simply does work that private institutions or individuals would otherwise do, no new avenues for expenditure or investment are opened. New avenues are required if there is to be a better balance between the rate of saving and the rate of investment.

Furthermore, the Federal Government is only one element of the situation. It will be necessary to persuade state governments, counties, and municipalities to undertake the same course of procedure. They must so adjust their taxation and borrowing programs as to draw their required finances from savings seeking investment, rather than from such sources as will place a burden on the operations of buying, selling, and manufacturing. This points to a general expansion of the income-tax policy, both individual and corporate, with perhaps a new emphasis on earned versus unearned income as against property-tax, sales-tax, and other similar policies. Some of these taxes, such as that on gasoline sales, are useful and easily collected, and their elimination is not urged. It is only pointed out that they offer no creative possibilities such as appear in the income tax.

The Centralized Public-Works Control for which the American Engineering Council has been working for more than a decade, is necessary for carrying out the suggested program. A similar centralized control must also be developed in the governmental structure of the states, counties, and municipalities.

While the suggested program may appear to require a larger amount of public works, borrowing, and taxation than customary, this is not necessarily true. It is possible that no greater total expenditures will be required over the course of a single business cycle than usual. Certainly the proper timing and distribution of taxation, borrowing, expenditure, and repayment would have a highly remedial effect on business conditions, even though the total amounts involved are not materially greater than normally.

The Balance of International Payments, published in the yearbook of the United States Department of Commerce, may be made a most valuable instrument in any system of control. This document, next to the internal balance sheet of the receipts and expenditures of the Government, is the most important document prepared for the guidance of the general financial and business operations of this country. It is composed of the debit and credit items of exports and imports; of loans, investments, and deposits made by this country to foreign countries and vice versa; the changes of long-term foreign investment in the United States and of the debts in American banks to foreigners; the exchange of gold and paper money; and a large number of miscellaneous so-called "invisible" items such as ocean freight, interest on private and public funds, war-debt receipts, etc.[9] The importance of this document is in connection with the foreign-debt situation and with recent extension of credit to foreign countries.

The duty of those in control of the international financial operations of this country clearly lies in keeping a close eye on the balance of international payments to the end that no greater credit extensions be made than can be repaid by imports, foreign travel, and the like. A careful scrutiny of this balance sheet indicates that any further extension of foreign loans at this time is unwarranted on the basis of any practical possibility of increasing the counterbalancing items.

A further disregard of the implications of this highly important document may lead to such serious involvements in foreign conditions as to make the recovery in this country less assured and decided—and that without compensating advantages to the world situation.

In the event world conditions should become increasingly chaotic, the organization of world finance and commerce will be best initiated in the smaller units of the natural economic empires. The British Empire furnishes one such example, and the United States and its dependencies another. Such limited organizations having non-predatory attitudes toward the rest of the world may offer the best hope for world progress in the immediate future. The tools of control for the needed international flow of goods and credit lie in the Government's supervision of the extending of foreign credits, and in the application of the tariff. Both the tariff and the control of credits should be viewed from the standpoint of this total situation in a way in which they do not appear to have been viewed in the past.

The Stabilization of Money is another possibility for large-scale governmental and financial action. The importance of the value of money (or, what is the same thing, the general price level as reckoned on a properly selected index) is plainly in evidence in the present situation. The fundamental disaster has been the continually lowering level of commodity prices. The situation raises the question of the possibility of a definite and immediate control of the uncontrolled and widely fluctuating value of money.

The seriousness of the lack of control is beyond words to express, because it is probable that the world is in full movement on a secular decline, with minor short-lived upturns only in prospect. It is important for governments and financiers to reconsider their attitudes on this question. What is required is a steadfast attempt to discover a safe and reliable means of controlling the value of money. Instead of being a question that is tabooed or ignored, it should be looked upon as the most important financial subject to which those in charge of the world's money can devote their energies

[9] This balance cannot, of course, be brought within a cent as has to be done with the receipts and expenditures of an individual or a firm. While some of these items are more or less exact, others are estimates. During the period from 1923 to 1929 the balance was brought to within an amount varying from four to fifty million dollars of discrepancies and omissions; and over the period the positive and negative discrepancies have tended to wipe each other out. The larger discrepancy for the year 1930 is being studied, and will doubtless be properly revised.

and their attention. There should be no rest until every possibility has been canvassed.

The Condition of Agriculture does not lend itself so readily to practical recommendations as do some of the other elements of the general economic problem that have been considered. Certain of the lines of action suggested would, however, have an immediate and useful effect on the situation. This is especially true of the control of the price level. To no other group would a stabilization of money be more helpful. The conditions of agriculture are such that it has no inherent self-protection. As already stated, the inflation of that industry was urged and aided by the Government, for purposes connected with the carrying on of the World War. The deflation hit the farmers in full force long before it was felt by other industries.

The Government Reclamation Policy should be considered from now on with a great deal of care. No new areas should be brought under cultivation with public funds until every aspect of the increased production which will follow has been canvassed. It is quite possible that the Government should be pursuing a policy completely opposite to that of reclamation: namely, the surveying of farm lands to determine marginal areas which should be reforested, and the purchase of them for that purpose. This possibility is already being canvassed to some extent by the federal and state governments. It could be carried on and financed by proper timing in the business cycle, in such a way as to improve the general situation.

The Decentralization of Manufacture which is engaging the attention of industrial leaders offers a useful method of striking a balance between agriculture and manufacturing. While a few industries, like the manufacture of steel, must be organized on a scale so large as to surround themselves inevitably with urban conditions, this is not true of the greater number. They can properly be divided into smaller units. The present tendency is to locate units in smaller communities, in closer contact with rural conditions. This tendency should be encouraged, for the sake of human as well as business values. Besides offering a greater stability to the life of the workman through the opportunity for gardens, poultry yards, and the like, it also furnishes a marginal region in which any needed transfers from manufacturing industry to agriculture and vice versa can be safely made as changing conditions may require.

A Purposeful Search for Profitable Investment will be required if this country is in fact nearing a saturation point in mechanized equipment. Heretofore the demands for capital to supply railroads, construction, and the manufacture of bicycles, automobiles, war materials, and other equipment have absorbed the money available for investment.

What is there now of this same sort which will draw the idle millions of the years to come into profitable industry? Will it be the building of houses? If so, the cost of their construction will have to be diminished by new methods and by a better equalization of labor rates as between the building trades and those whom the buildings are to house, with due consideration to the annual earnings of building-trades labor. When the investment market accustoms itself to a lower rate of return, capital will flow into this channel. Furthermore the increased standard of living contemplated will enlarge the market for household furnishings, equipment, and conveniences.

Increased investment is also possible in small items totaling a large amount in industries well established and running. Such engineering analysis of the advisability of investment in new equipment as was outlined in a paper recently presented by Vorlander and Raymond[10] may well become a vital link in the maintenance of the general economic prosperity of the country. The recognition of this by financial authorities and the organization of the latter to finance the multitude of small investments required may, in the aggregate, furnish a sufficient channel for investment to answer the purposes of sustained prosperity for many years. To make this effective, however, the financial leaders must recognize the economics of the situation, and must consciously organize for this specific purpose.

A helpful procedure would be to set up an engineering staff in each banking organization, which staff should be as aggressive in searching for opportunities for sound investment as the sales departments have been in enlarging the list of depositors.

This discussion again raises the question of public works. Herein lies an almost limitless field for the investment of private savings for public good. Highways, bridges, parks, undeveloped wild areas, public buildings and institutions for education and rational enjoyment, and many other like avenues offer a field for investment that is socially profitable and economically stabilizing. In part the requirements may be realized and met by private initiative, but to a large extent recourse must be had to taxation. Moreover it is in the interest of general business, when the rate of saving is larger than the rate of investment, to withdraw money from private hoarding and use it for the public benefit. This is true because it is becoming plainly evident that money which is neither spent in consumption nor invested in capital goods is impotent in the hands of the one who saves. It does not benefit the saver, and it injures society.

Industrial Proposals, including plans concerning life and disability insurance, pensions, and unemployment insurance, are deserving of most careful study. The necessity, however, for such private relief as is suggested, particularly of unemployment insurance, will diminish in proportion as the governmental action outlined herein succeeds.

Trade Associations should be further developed. They should not only be permitted but compelled to gather the basic information relating to their industries and to make it public. Wherever the nature of the product permits, the published information should include weekly or monthly reports on output, sales, stock on hand, unfilled orders, cancelations, and capacity util-

[10] "Economic Life of Equipment," by H. O. Vorlander and F. E. Raymond. Presented at Annual Meeting of A.S.M.E., Dec. 2, 1931.

ized. The use of such information will assist in planning everything that can be done industrially to maintain a steady flow of business. Ignorance of or inattention to such information has in the past resulted in entire industries adopting unwise policies which have contributed to economic unbalance.

Trade associations might profitably be required to set up not only standard principles and uniform methods for costkeeping, but also standard practices for financial reports to stockholders. It is wise as a matter of public policy to require that all standardized financial reports be made public, even though the securities of the companies are not listed or held by the public. Such a provision would encourage new money to flow into those fields where investment is likely to be profitable, rather than into those where a loss may be easily incurred. Each trade association should develop sound methods for the introduction of new processes and machines into its field, so that the industry may make needed changes with the minimum amount of economic disturbance and distress to individual workers.

There are many industries manufacturing products of comparatively inelastic demand in which man-hour studies for the total required volume of output could be usefully undertaken. The exact effect of new processes on unemployment and the labor requirements of expanding and contracting enterprises could then be more accurately foreseen and provided for.

The trade associations should make a thorough, continuing study of consumer credit and instalment selling. It would be most useful at any given time to know whether instalment buying was increasing or decreasing; whether the payments were being made promptly or were being delayed; and what percentage of the goods sold are taken back. Information of this character would be exceedingly useful in developing policies of economic control.

A Continuing Shortening of the Work Week should receive the serious consideration of industry and commerce. It is probable that the distribution of wealth between consumers and investors could be much improved by adopting new working hours and overtime policies. For instance, it is reasonable to believe that if in an industry normally operating fifty hours a week the working hours were shortened to forty, with fifty per cent overtime pay up to forty-five hours and one hundred per cent overtime pay beyond that, the influence of the change would be in the direction of maintaining good business for the following reasons:

1 Shorter normal working hours would constitute a permanent "spread of employment."

2 As business improved and the number of hours became too small, the overtime rate, effective up to forty-five hours a week, would assist in increasing the distribution to consuming power necessary to maintain the increased business. The extension of working time to where one hundred per cent for overtime applied would add still more to consuming power.

3 The cumulative overtime would act as a damper to unwise expansion of activity. The business man would calculate more carefully before allowing rein to his enthusiasm. When he did conclude that the increased overtime was necessary, his decision would be justified by the added consuming power involved.

Such a policy, if inaugurated, must be on an industry-wide basis. Otherwise the progressive and socially minded employers would be at a serious disadvantage.

Employment Agencies, in a country-wide, thoroughly coordinated system, with a well-trained and efficient staff, are essential. This is a pressing, unfilled need. The problem of employment is a highly specialized and essential one to any plan of controlling economic forces.

Production by Agreement to reduce output, or the allocation of business to different firms under normal business conditions, is an unwise policy. Such arbitrary control leads inevitably to stringent Government regulation and official price fixing.

The Committee repeats that it realizes the issues discussed in this progress report have not been thoroughly studied. However, the issues presented comprise the broad outlines of the problem of economic balance, and they are subject to determination. There is an evident need for a more detailed and exhaustive consideration of them, and of others not mentioned.

It is clear that the arbitrary control of modern industry and commerce, in all their ramifications, complexities, and details, is beyond the power of human beings. The influences now at work must continue to govern its details. In particular, the profit motive and the active force of competition must be retained in such effective operation as will give society the benefit of the continuous improvement in methods and lowering of costs which they are capable of giving. They must be restrained in their destructive and unsocial manifestations.

It should be remembered that an experimental element of large dimension will always be present in any new project of social and economic control. Furthermore experimentation in social matters is serious, because it is for the sake of human beings. Therefore any such work must proceed with wisdom and caution. However, since there has emanated from an uncontrolled development so many undesirable results, there is justification for taking such chances as may be involved in developing a rationally controlled economy.

The problem of the relation of consumption, production, and distribution is one of supreme importance. More and more will it command the attention and devotion of the most intelligent, unselfish, and far-seeing men and women of the body politic. There is no human problem which compares with it in difficulty, in magnitude, in hopefulness. It is world-wide in its import and study. What is being contemplated is nothing less than a purposeful changing of the course of history.

To such an undertaking the highest human capacities of our time must inevitably devote themselves.

R. E. FLANDERS, *Chairman*
L. P. ALFORD
F. J. CHESTERMAN
DEXTER S. KIMBALL
L. W. WALLACE.

MECHANICAL ENGINEERING

Vol. 54 JUNE, 1932 No. 6

GEORGE A. STETSON, *Editor*

Constructive Economic Analysis

A SIGNIFICANT report prepared by a committee of the American Engineering Council on the interrelation of the problems of consumption, production, and distribution will be found published in full in this issue. It deserves the careful study of all engineers. Comment on it to the American Engineering Council is solicited. A sincere attempt is being made by engineers to contribute the best of their thinking to a tremendous and vital national economic and social problem. The Council and its committee deserve enthusiastic support, and their report is entitled to sympathetic and constructive criticism.

New York's Registration Law

ELSEWHERE in this issue is a résumé, with certain quotations, of the professional engineering registration law of the State of New York recently signed by Governor Roosevelt. While this law affects only engineers practicing in the State of New York, it is of interest to all professional engineers because it is an indication of the trend toward a wider adoption of such laws and of the increased severity of their requirements. For these reasons, if for no others, the law and the tendencies it represents should be thoughtfully considered by all engineers. Engineers cannot afford to remain ignorant of legislation that affects them so vitally.

Another new and similar New York State law deals with the registration of architects. The two laws place engineers and architects on an equal footing in cases where the two professions overlap. Licensed professional engineers and licensed architects are given equal rights to file plans for buildings or structures. This corrects a situation that had given rise to ill feeling between the two groups.

English for Engineering Students

THE Society for the Promotion of Engineering Education this summer devotes one of the sessions of its summer school for teachers of engineering to the subject of the teaching of English. At the Ohio State University, Columbus, Ohio, from July 11 to 28, inclusive, teachers of English to engineering students will have the privilege of learning more about their jobs from an able staff consisting of well-known teachers of English, college executives, and others from outside the field of education. A large attendance will be convincing evidence that college executives and the teachers themselves are determined that English shall be more effectively taught. Incidentally, any teacher of engineering students will find the session a profitable one for himself personally, and also that it will better fit him to cooperate with his colleagues of the English department in turning out better-equipped and more cultured graduates.

Industrial Housing in Russia

ONE of the great problems of the Soviets is to keep men on their jobs, which, in the long run, can be done only by making working conditions attractive. The most powerful incentive in this direction seems to be the provision of model living conditions for the workers which they cannot obtain elsewhere. It is for this reason, for example, that at the Moscow Ball- and Roller-Bearing Plant, officially opened March 29, 1932, a workers' settlement is being built adjoining the plant. Three five-story apartment houses have been finished and are already occupied, and six more are nearing completion. A group of small standardized houses are also being set up. The "kitchen factory" will soon be ready to supply meals at low cost. A playhouse, motion-picture theater, school, nursery, and clinic are under construction, and provision is being made for establishing special truck gardens near the settlement to supply the workers with fresh fruit and vegetables.

This provision of living quarters and social service near the plant will add considerably to the cost of the plant. While it is partly a matter of necessity, as even in Moscow there is a lack of housing within a convenient distance from the plant, it is a wise investment as the workers will come to look upon the plant as their home and will be much more contented than they would be if they were forced to live in drab hovels or unsanitary rooming houses.

Engineers in Civic Service

AN OFT-REPEATED criticism of the engineer is that of his apparent indifference to social and civic problems in which his knowledge and experience may be of special value. Legislators and administrators of government, whether national, state, or local, are admittedly ignorant of many of the factors of prime importance to the success of their acts and decisions, and are frequently wrongly advised by agents of special interests in matters that admit of straightforward solution by engineering methods. A careful and constructive scrutiny of public affairs, conducted in a manner devoid of class interest and personal offense, is one of the helpful services that engineers can render individually and collectively in their communities. The weight of their expert opinion on matters involving engineering principles will give courage and conviction to public officials

who may be honestly confused or led astray by ignorance and illogical thinking. With so many departments of public business depending definitely upon engineering and technology and with so few engineers in public life, the necessity for disinterested professional guidance becomes an obligation on the engineering fraternity. Furthermore, state and municipal engineers frequently welcome the backing which their fellow-practitioners in private enterprises can provide for them.

It seems logical, therefore, for engineers to extend their usefulness to society by offering more abundantly and in a greater number of communities the kinds of services that are rendered by engineering organizations in the states of Colorado and Minnesota.

The benefits from such organization extend beyond those which accrue to the community. They apply equally well to the engineering groups represented. By means of them a united effort can be made effective in public matters in which the professional and economic interests of engineers are vitally concerned, as in registration laws, building-construction and safety codes, standards, appointments to commissions, etc. And, by common endeavors and frequent cooperation, interprofessional and intersociety interests can be more certainly advanced. We commend to all mechanical engineers the desirability of promoting professional consciousness and coordination of interests and services, not only on a a national scale but also in local communities.

A New Idea in Diesel-Engine Drives

AN ABSTRACT of a paper presented by Alfred J. Buechi last year before a Japanese engineering society and published in the Survey of Engineering Progress in this issue of MECHANICAL ENGINEERING, presents a radically new conception of Diesel-engine operation—it lets the tail wag the dog with a vengeance. The Buechi system as known today consists in utilizing the exhaust gases of a Diesel engine to drive a turbine, which in turn produces compressed air for purposes of scavenging and supercharging the engine.

What Buechi proposes now, however, is essentially to make the engine simply a generator of high-pressure, high-velocity exhaust gases. Under these conditions all the power produced by the Diesel engine will be used to drive the compressor, while the useful power will be entirely generated by the exhaust turbine. It is pointed out that the efficiency of such an arrangement will be somewhat lower than that of a conventional turbocharged Diesel engine. Its flexibility, however, will be very great, as the speed of operation and power output of the exhaust-driven turbine can be varied within wide limits and will permit the operation of locomotives and other machinery where wide variations of speed are required without speed transmissions.

The application of Diesel engines to locomotive drive has been greatly handicapped by the fact that the Diesel engine is not flexible in the matter of speed changing, being in that respect similar to the explosion engines used in automobiles. It therefore becomes necessary to use intermediate transmissions, which have been built in the form of change gearing on automobiles, and usually as compressed-air, hydraulic, and electric transmissions on Diesel engines. While these forms of transmission have already been developed to a high state of economy and efficiency, they nevertheless constitute a serious drawback to the more extensive use of Diesel engines for locomotive drives because of their added cost, weight, and complexity of operation.

One cannot help asking oneself what might be the effect on railroad operation of the introduction of Pawlikowski's coal-dust Diesel engine with the Buechi power drive from a supercharger turbine. One result of the introduction of such a combination might be the possibility of increasing the power output of the locomotive without unduly increasing its size, thus meeting the exacting conditions of operation on certain roads in this country where to all practical purposes not an inch can be added either to the height or the width of the locomotive structure.

Economics for Engineers

STEVENS Institute of Technology will be the scene of the economics session of the Society for the Promotion of Engineering Education Summer School for Engineering Teachers. The date has been set for July 5 to 21, inclusive. The three-point program will include organization, content, and teaching of courses in economics, and related courses such as accounting, statistics, industrial engineering, engineering administration, and industrial personnel practices; lectures on economics by teachers, economists, and engineers; and lectures on current economic topics by men outside the educational field.

The times are demonstrating the importance of clear thinking in economics and the need for its extension among all classes of society. We can bear testimony to the extraordinary interest that engineers have recently displayed in economic theories and in related practices that are not in the special field of the engineer. While engineers would resent having laymen tell them how they should design bridges and power plants, some of them do not hesitate to set up programs for the cure of the world's financial, economic, and social problems after an elementary and unsystematic glance at present-day ills. As a result they frequently indulge in destructive rather than constructive criticism, or propound theories that have been set up and knocked down by man ever since the beginning of time. A familiarity with fundamental principles and the history of economic thought would save much confusion. Engineering colleges are giving more and more attention to economics and related subjects. The S.P.E.E. is performing a valuable service by improving the quality of the teaching of these important subjects to the young men who will have to face the problems that the next depression will bring.

The Basic Laws of Heat Transmission

(*Continued from page 414*)

temperatures up to about 300 F in pipes ranging from 1/2 to 3 in. I.D. is

$$h = 4G^{0.8} \text{ Btu/hr/sq ft/F} \quad [18]$$

The heat transfer and pressure drop in empty, baffled, and packed tubes have been studied by Colburn, Chilton, and King.[25] It was found that h could be increased up to about six-fold by packing the tube with pellets or inserting spiral turbulence promoters, at the expense of greatly increased pressure drop.

(*e*) *Gases Flowing Across Pipes.* If k and μ for air are expressed as functions of the mean film temperature t_f, Equation [12] can be reduced to the form

$$h = 8.2 \frac{G^{0.585}}{D^{0.415}} (1 + 0.000576\, t_f) \text{ Btu/hr/sq ft/F} \quad [19]$$

or if h_L is the coefficient per foot of pipe length,

$$h_L = 2.15 (DG)^{0.585} (1 + 0.000576\, t_f) \text{ Btu/hr/ft/F} \quad [20]$$

where D is the outer diameter in inches and G is the mass velocity, lb/(sq ft)(sec). For convenience, Equations [19] and [20] are plotted in Fig. 5. A somewhat similar plot is included in Chappell and McAdams[19(b)] excellent paper on this subject, but, as Drew and Ryan[19(g)] have pointed out, their values for pipes were based mainly on the data of Hughes, which were probably low (see Fig. 3).

If the pipes are arranged in multiple rows or bundles, and G is the mass velocity through the minimum free area, the coefficients will be somewhat higher than the figures given above for a single pipe. The value of h is higher when the spacing between pipes is reduced, and higher when the pipes are staggered than when they are arranged in line. Increasing the number of rows also increases the average coefficient for the bank. Under the usual conditions the coefficient for staggered pipes is from 10 to 30 per cent higher than for a single pipe. The foregoing should also apply approximately to other gases having values of k and μ not far removed from those of air.

(*f*) *Air Flowing Over Plane Surfaces.* For the special case of air at atmospheric pressure and temperature flowing over smooth plane surfaces the following formula, derived from Equation [13], may be used:

$$h = \frac{0.56\, v^{0.75}}{L^{0.25}} = 0.56 \sqrt[4]{\frac{v^3}{L}} \text{ Btu/hr/sq ft/F} \quad [21]$$

where v is the velocity in feet per second and L is the length of the surface in feet. Due to the effect of free convection, at velocities less than 15 ft/sec the formula

$$h = 0.8 + 0.22v \text{ Btu/hr/sq ft/F} \quad [22]$$

will give more accurate results when the characteristic dimension of the surface is of the order of magnitude of one foot.

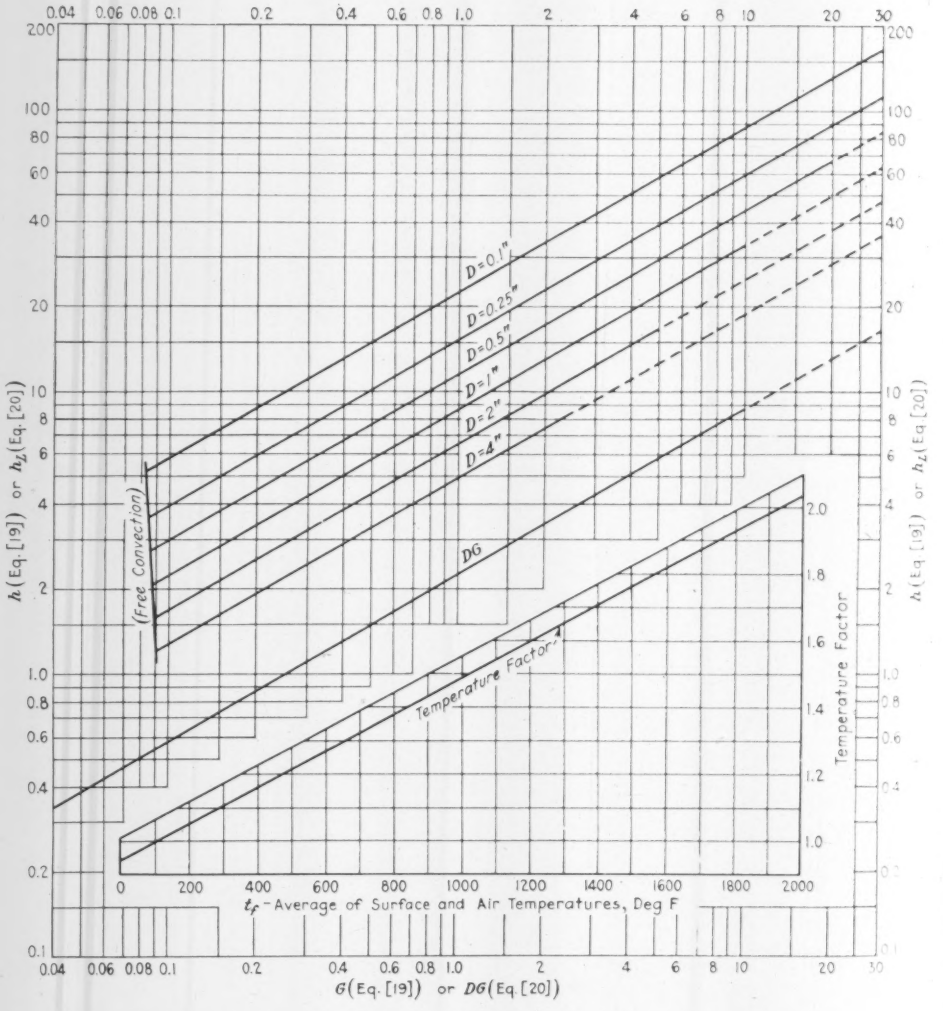

FIG. 5 HEAT-TRANSFER COEFFICIENTS FOR AIR FLOWING ACROSS PIPES OR RODS

For rough surfaces of this size, the few available data may be represented by the formula

$$h = 1.0 + 0.25\, v \text{ Btu/hr/sq ft/F} \quad [23]$$

Effect of Radiation

It must be remembered that the coefficients given in this article refer only to the forced-convection component of the heat transfer, and do not include radiation, which may be a considerable item in some cases. At moderate temperatures and fairly high velocities the additional effect of radiation is usually small, and if the fluid is a liquid it does not appear at all. This will be discussed more fully in the succeeding article of this series.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICAL ENGINEERING (See also Mechanics: Vibration Characteristics of Aircraft-Engine Crankshafts)

Soviet Aviation

THE following figures are significant. This year several additional lines totaling 4882 km are to be opened, of which 1890 km will be hydro lines. In addition a total of 5000 km of short lines will be opened and 150 flying fields are to be built. At the end of 1931 there were 41 air lines in regular operation. An air line between Leningrad and Moscow equipped for both day and night flights was recently completed. The planes will carry up to eight passengers, besides mail and freight. Progress has been made in adapting all Soviet air lines to year-round service. The Civil Aviation Scientific Research Institute completed in October, 1931, the first all-steel stainless-steel electrically welded plane known as the "Steel-2," while the Leningrad Scientific Research Institute for aviation has completed preliminary detail drawings of an all-metal airship with a capacity of 8000 cu m. The outside of the body is to be constructed of a special aluminum alloy known as "Kolchug."

	Length of lines	Distance flown	Passengers	Mail	Freight
	(kilometers)			(metric tons)	
1929	17,542	4,047,000	13,900	89.6	541.3
1930	29,281	5,889,000	17,800	143.8	206.4
1931	44,900	7,000,000	23,000	375.0	300.0
1932 (plan)	55,000	10,500,000	40,000	— 2000 —	

Airplane test control was applied to 615,000 acres in 1931, while the Udarnik State Farm in Central Asia used airplanes in its spring sowing work with successful results. 1500 hectares (3700 acres) were planted in wheat on March 16, the planes sowing 16 hectares (40 acres) per hour. They flew at a height of 18 m and used 45 kg of seed for each hectare. In 1931 experiments were carried on in sowing rice by airplane over an area of 100 sq km in the Kuban district of the North Caucasus. It is expected this year to sow in rice 50,000 hectares. Planes will be used this year for laying smoke screens over orchards and vegetable gardens to protect them against frost, for fertilization work, and for breaking up fog by electrical methods. (V. A. Zarzar, Chief of Automotive Section, State Planning Commission, in *Economic Review* of the Soviet Union, vol. 7, no. 8, April 15, 1932, pp. 178–180, 3 illustr., *ds*)

Application of Practical Hydrodynamics to Airship Design

THE design of a large high-speed airship is primarily a structural problem, in which the most important stresses are those due, directly or indirectly, to aerodynamic forces on the surface of the hull. The force on any small element of the surface is most conveniently divided into two components, respectively tangent and normal to the surface. The tangent or skin-friction forces are so small per unit area that they are structurally almost negligible compared with the normal forces; yet their total integrated resultant is responsible for almost the entire drag of the hull, whereas the normal components of pressure are so nearly balanced over a good hull that their net resultant is practically zero. The interreaction of these very substantial forces is, of course, through the medium of stresses in the hull, and in combination with fin and inertia forces they are essential not only from a structural standpoint but also in the consideration of stability and control. The distribution of velocity and skin friction can also be indirectly determined from the normal force distribution. An accurate determination of the latter and its effect is therefore of the very first importance. (Ralph H. Upson and W. A. Klikoff, in Report No. 405, *National Advisory Commission for Aeronautics*, 1931, pp. 3–20, 12 figs., short bibliography, *t*)

High-Speed Seaplanes

IN A LECTURE before the Royal United Service Institution last week, Wing Commander A. H. Orlebar gave some interesting details concerning the ease and difficulties of control of Schneider Trophy seaplanes. It appears that although the racing seaplane is very much like any ordinary airplane to fly, conditions at the take-off and landing are peculiar. When first accelerated on the water it tends to swing uncontrollably to the left until sufficient speed is gained for the rudder to become operative. Owing to the clouds of spray the pilot is very conscious of uneven water. Once in the air the machines are very easy to fly, and control is quite straightforward. Last year's machines, for instance, could be flown at a speed of about 330 mph with hands and feet off the controls. There is, according to Wing Commander Orlebar, little sensation of speed. In landing, the seaplane has to be flown at 160 mph if it is not to sink so rapidly that the right moment to flatten out becomes difficult to judge. Once on the water, deceleration is so rapid that the pilot must brace his shoulders back lest he be thrown forward and break his goggles on the windscreen. All the accidents last year occurred either at take-off or on landing. Wing Commander Orlebar confessed that the races for the Trophy had, in effect, only produced a freak aircraft, which could do nothing useful, but he was of the opinion that a vast amount of knowledge had been gained, and that the money spent had taught lessons from which concrete results could be deduced. (*The Engineer*, vol. 153, no. 3977, April 1, 1932, p. 357, *p*)

AIR COMPRESSORS

A British Air Compressor

THIS compressor, developed by J. Halloway and built by the Laycock Engineering Co., of Sheffield, England, has two cylinders and four-stage compression. There are two pistons in each cylinder but they do not operate as opposed pistons in the accepted sense, since both move simultaneously in the same direction. The travel of the upper piston is smaller than that of the lower, however, so that the air between them is compressed. The designers call the lower piston the compression piston and the upper one the balance piston. The compression piston is connected in the ordinary way to the

crankpin of the crankshaft, but the balance piston is driven from the compression piston through a rocking lever, Fig. 1, whose arms are set at about 60 deg. The upper arm is connected by a pair of links to the crosshead, while the lower arm is attached by links to the balance piston. The stroke of the compression piston moves the upper arm over the arc *GH*. The lower arm at the same time oscillates over the arc *HJ*. Since the pistons only move in the vertical plane, only the vertical component of the arm through which the arms of the rocking lever travel affects their movement. Hence, while the compression piston moves through a vertical distance of *HG*, the balance piston, connected to the lower arm, only moves a distance equal to the vertical distance between *J* and *H*. In actual fact, owing to the obliquity of the connecting link, the distance traveled is even less. Thus, on the upward stroke the space between the two pistons is continually lessening.

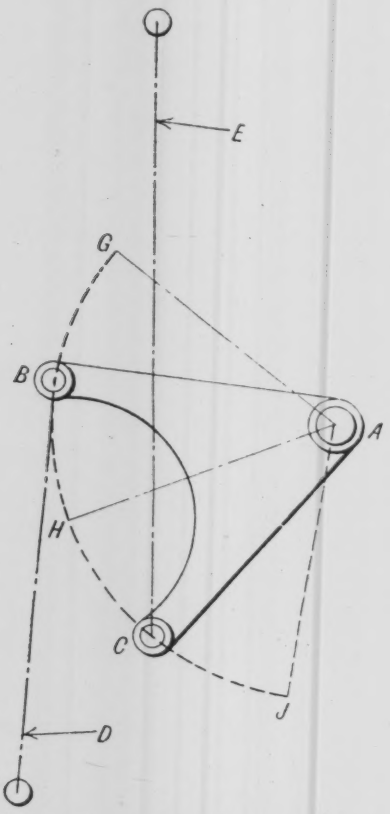

FIG. 1 ROCKING LEVER OF AIR COMPRESSOR

An interesting feature of the mechanism is the balance obtained at the top dead center. In this position the two arms of the rocking lever are respectively at *G* and *H*, while the air between the pistons is at delivery pressure. This pressure is exerted on the top of the compression piston, and in an ordinary machine would be transmitted to and carried by the crankpin bearing and crankshaft bearings, which would transmit the load to the frame. Here, however, an equal pressure is exerted on the balance piston. This load is transmitted through the link to the lower arm of the rocking lever, and hence via the upper arm to the compression piston, the pressure upon which it balances. There is then at this point of the stroke no load on the crankpin whatsoever, and theoretically at least, even if not practically, the connecting rod could be disconnected from the crank. At any other part of the stroke, of course, there is a load on the crankpin, since at half-stroke—for instance, when the rocking lever is in the position shown in the diagram, Fig. 1—the moment of the force transmitted by the link from the balance piston about the center of rotation *A* of the rocking lever is less than that from the compression piston. Owing to the fact that at any and every point of the stroke the limbs connecting the two pistons of the rocking lever are in tension, these rods may be made quite light without a stress of 3 tons per sq in. being exceeded. The introduction of the balance piston, it is claimed, eliminates all shock and hammering on the crank and bottom end bearings at the point of highest compression, while the turning moment is even more, with the result that a very smooth-running, quiet, and vibrationless machine is obtained.

It is claimed that a machine with a cylinder diameter of 5 in. and a compression piston stroke of 6 in. can compress 50 cu ft of free air per minute when running at 450 rpm. The original article shows a cross-section and elevation of a 100-cu ft compressor, and gives the details regarding the cycle of operations. (*The Engineer*, vol. 153, no. 3980, Apr. 22, 1932, p. 458, 4 figs., *d*)

AIR CONDITIONING

The Labus Psychrometric Chart

THIS chart, copyrighted by O. A. Labus, is a network chart with the primary coordinate system of relative humidity plotted against wet-bulb temperature, both on uniform scales. On this primary coordinate system lines of constant absolute humidity (in grains per pound of dry air) and lines of constant dry-bulb temperature are located, in accordance with accepted psychrometric principles, for the single barometric pressure of 29.92 in. of mercury. The lines of constant absolute humidity are also lines of constant dewpoint, and are labeled with values of absolute humidity and dewpoint in the skeleton chart Fig. 2 of the original article, although in the original chart an auxiliary scale is carried along the abscissa to give the absolute humidity. A scale for the secondary variable, "total heat," is placed adjacent to the scale of wet-bulb temperature, upon which it depends. In form, then, the Labus chart is quite similar to the Hill chart, for on the latter, dewpoint temperature, with dependent secondary variables, is plotted against dry-bulb temperature, and lines of constant wet-bulb temperature and constant humidity are drawn on this coordinate system.

A numerical example is given. In addition to it but distinct from the main coordinate system of the chart, the specific volume of bone-dry air and the specific volume of air saturated with vapor in cubic feet per pound of dry air are plotted against dry-bulb temperature. On the basis of relative humidity it is possible to interpolate between these lines and secure the humid volume. The chart itself is not reproduced because of lack of space. (C. O. Mackey, Assistant Professor of Heat Power Engineering, Cornell University, in *Heating and Ventilating*, vol. 29, no. 3, Mar., 1932, pp. 40–42. Compare article by the same author, "A Review of Psychrometric Charts," June, 1931, p. 50, July, 1931, pp. 64, and August, 1931, p. 59, of the same publication. Compare also article by K. P. Brace, Air Condition Engineer, National Carbonic Machinery Co., Chicago, entitled, "The Use of the Labus Chart for Air-Conditioning Operation," in the March, 1932, issue of *Heating and Ventilating*, pp. 43–45, 2 figs., *dp*)

APPLIED MECHANICS

Physical Properties of Steel After Plastic and Yield-Point Extension

CRYSTALLOGRAPHERS distinguish between a "shift" and a translation or gliding in crystals. In the latter case the amount of the glide is undefined, while shifts are glidings of perfectly definite amounts. The paper describes experiments on wires and rods and gives a brief review of the single-crystal experiments of Joffe and of the elastic-hysteresis theory of Prandtl. Next is described the effect of plastic and

yield-point extension on the physical properties of steel.

From this it would appear that whereas steel stretched by yield points possesses very different elastic properties from that stretched to the same extent by a single loading, the other properties, such as slip bands, density, electric resistance, etc., do not appear to differ appreciably in the two cases. (Prof. J. Muir in *The Journal of The Royal Technical College*, vol. 2, part 4, Jan., 1932, pp. 571–586, 4 figs., *e*)

CORROSION

The Effect of Oxygen on Gaseous Hydrogen Sulphide Corrosion of Tank Steel

THE severe corrosion of equipment that is caused by the presence of hydrogen sulphide in oil and gas has been described in detail by several authors Such corrosion, termed "low-temperature hydrogen sulphide corrosion," presents a somewhat different problem from the "high-temperature hydrogen sulphide corrosion" that is encountered in refinery operation and which has been described by various investigators of refinery corrosion.

This matter is of particular importance to sour fields, that is, producing fields in which the oil and gas contain hydrogen sulphide. (These fields produce between 10 and 15 per cent of the total domestic crude-oil output.) The mechanism of the attack of the hydrogen sulphide upon steel presents a complex theoretical problem for which an adequate explanation has not yet been advanced. The report covers a survey of former studies of hydrogen sulphide corrosion.

The investigation has shown that the presence of oxygen is necessary to cause corrosion, and that apparently its elimination is the only way to prevent corrosion. The corrosion proceeds proportionately with the time, indicating that the scale formed on the metal in this case is of a non-protective character. (John M. Devine, C. J. Wilhelm, and Ludwig Schmidt, all of the Petroleum Experiment Station, U. S. Bureau of Mines, Bartlesville, Okla., in Report of Investigations, Department of Commerce, Bureau of Mines, R. I. 3160, Feb., 1932, 19 pp., illustrated, *ep*)

ENGINEERING MATERIALS (See also Applied Mechanics: Physical Properties of Steel After Plastic and Yield-Point Extension; Corrosion: The Effect of Oxygen on Gaseous Hydrogen Sulphide Corrosion of Tank Steel; Metallurgy: Hardening of Steel by Quenching in Pectin Solutions)

Illium—A Metal for Instruments

ILLIUM is an alloy composed principally of nickel, chromium, copper, molybdenum, and tungsten, with smaller amounts of iron, manganese, silicon, and carbon. It is claimed to be capable of withstanding the action of the common corrosive reagents at all ordinary temperatures except wet chlorine or hydrochloric acid in strength exceeding 5 per cent.

In the field of measurement it has found application for calorimeter bombs, crucibles, thermocouple tubes, pyrometer tubes, and instrument housings. Its density protects against leakage under pressures of 1000 lb per sq in. and more. Its melting point is around 1300 C (2373 F). (W. D. Staley, General Manager, Burgess-Parr Company, Moline, Ill., in *Instruments*, vol. 5, no. 3, March, 1932, pp. 65 and A22, illustrated, *d*)

Creep Tests of Cold-Drawn Bridge Wire

THIS article deals with tests of wire originally used in the structures of the Ambassador Bridge between Detroit and Windsor, and the Mt. Hope Bridge in Rhode Island.

In each test the wires were loaded to 74,000 lb to the square inch and maintained for 24 hr. This was then raised to 94,000 lb for another 24 hr and then to 113,000 lb, this maximum stress being maintained for two weeks in the case of some of the wires and for two months in others.

Some small creep, uncertain in amount, was observed during the 24-hr tests at 74,000- and 94,000-lb stresses. In tests for two weeks at a stress of 113,000 lb, the rate of creep diminished with the time. The length had not, however, stopped increasing in two weeks, but did cease growing after two weeks in the longer tests. Total extension averaged 0.023 per cent after two weeks, and 0.024 per cent after two months.

Tensile tests made of wires which had been subjected to these creep tests showed, with few exceptions, that the ultimate strength had been improved as compared with the original condition. Wires so treated were wound into coils with a diameter of $19\frac{1}{2}$ in. and left coiled for months. Subsequent tests disclosed no injury from this procedure. (*The Iron Age*, vol. 129, no. 16, Apr. 21, 1932, p. 915 in text and p. 20 in advertising section, *e*)

The Mercury Industry in 1931

BECAUSE of the application of mercury in double-fluid power plants, the following information may be of interest. Preliminary figures covering mercury output in 1931 indicate that approximately 24,750 flasks, valued at $2,162,000, was produced. These figures represent an increase of 15 per cent in quantity over that produced in 1930. The increased output of mercury in 1931 is noteworthy as compared with the considerably lower production recorded for most of the metals in the same year. The average quoted price of mercury was 24 per cent lower in 1931 than in 1930, and declined from the high monthly average of $103 a flask at New York in January to the low monthly average of $66 in December. Stocks of mercury in the hands of producers increased considerably during 1931, and by the end of the year production was suspended at most of the mines.

Imports (general) of mercury in 1931 were only 356 flasks, compared with 2943 flasks in 1930 and 14,292 flasks in 1929. Of the total imports in 1931, 350 flasks were from Spain and six flasks from Mexico. Imports for consumption were 549 flasks. Stocks of mercury in bonded warehouses decreased from 305 flasks at the end of 1930 to 88 flasks at the end of 1931. (*Mineral Market Reports*, U. S. Bureau of Mines, no. M.M.S. 103, Apr. 8, 1932, 2 mineographed pages, *g*)

"Personality" or "Timbre" of Tool Steel

STEEL has a definite "personality," something which also characterizes human beings, and the great confusion in existing data on steel is due to this difference in "personality," a term which the author replaces by the term "timbre." This has been defined as the inherent property of tool steel, independent of analysis, which influences the degree of hardness penetration and width of allowable quenching range. The author himself has developed a "timbre" test which indicates that "timbre" exists not only in tool steels but also in various alloy steels.

"Timbre" has been reported by other investigators as having an effect upon the surface life. Steel should therefore not be purchased indiscriminately with chemical composition and

cleanness as the sole specifications. The author recommends a test for the determination of hardenability, which he amplifies by including the width of quenching range due to varying the quenching temperatures over a certain range. Briefly, the test consists of quenching disks of steel which have been step ground in $^1/_{32}$-in. steps. These disks are quenched in a special brine spray and broken for fracture or cut in two and etched. For any temperature the hardenability number is taken as the numerator of the fractional thickness in 32nds of an inch of the thinnest section to have a core after this operation. The relation between "timbre" characteristics and normality of steel and its other properties is discussed. (D. F. Shepherd, Chief Metallurgist, Ingersoll-Rand Co., Phillipsburg, N. J., in *The Iron Age*, vol. 129, no. 16, April 21, 1932, pp. 916–919, 10 figs., *et*)

Wrought Beryllium-Copper for Electrical Parts and Springs

ADDITIONS of about 2.5 per cent of beryllium to copper produce alloys which are approximately six times as hard and five times as strong in tension as the original copper. These alloys, which Siemens-Halske engineers have called "be-bronze," have just recently been produced in wrought form in Germany. Be-bronze can be drawn, rolled, pressed, and stamped, and its properties may be modified by heat treatment. The heat-treated be-bronze has a high elasticity and a high resistance to fatigue, and has been used for highly stressed springs. Leaf springs made of this alloy have been subjected to repeated stress as many as 25,000,000 times without sign of fatigue, while similar springs of phosphor bronze failed after an average of 400,000 vibrations. Spiral springs of be-bronze have withstood 3,000,000 compressions; springs of standard spring steel have failed after 2,000,000. Be-bronze is especially adaptable for springs to replace bronze springs in applications where electrical conductivity as well as high resistance to continuous alternate stress is a factor, such as motor brush-holder springs, and springs for automatic telephones.

Beryllium is not a new metal, but up to eight years ago it sold only in minute quantities at $5000 per lb. It is one of the most commonly occurring metals, yet it has been only through persistent research that economic methods of extraction have been developed. And the price has been dropped until beryllium alloys can be marketed at a price that makes them commercially available. Beryllium is 30 per cent lighter than aluminum, has a higher melting point, 2322 F, higher electrical conductivity, and is so hard that it will scratch glass. But its immediately most valuable property is that it will alloy with copper, nickel, cobalt, aluminum, and steel to form alloy metals of remarkable new properties. Small properties of beryllium with the common metals produce alloys of great hardness and strength.

Be-bronze with 2.5 per cent of beryllium is easier to roll than most bronzes. It has already been produced in the form of wire, sheet, and tubing. It can be die-forged at between 1110 and 1290 F. Various heat treatments have been applied to the alloy. One heat-treated wrought alloy showed a tensile strength of 82,000 lb per sq in. and an elongation of 21 per cent. A 3 per cent alloy, after heat treatment, showed a tensile strength of 172,000 lb per sq in. and an elongation of 2 per cent. It is even possible by suitable heat treatment to attain a hardness of 400 Brinell in these alloys. Thus it offers possibilities as a construction material where hard wearing surfaces together with high corrosion resistance are needed. It has been applied with great success to the manufacture of motor and generator commutator segments, giving greater conductivity than copper and much longer life because of its hard wearing surface. While exact data are not available on the corrosion resistance of be-bronze, it is stated that it is more resistant than ordinary compositions of bronze, and should therefore be of value for parts of machinery used in chemical processing. (Interview with Dr. K. G. Frank, Consulting Engineer, Siemens & Halske Co., in *Product Engineering*, vol. 3, no. 3, March, 1932, p. 108, *dpA*)

FUELS AND FIRING

Evolution of Ammonia in the Carbonization and Gasification of Coals

PREVIOUS research has shown that lime added to a strongly caking or medium caking coal increases materially the ammonia yield when the coal was heated in stages up to 1000 C (totaling nine hours of heating) in an atmosphere of hydrogen. There has, however, been some doubt as to how far liming could be relied upon to give more ammonia with different coals. In order to throw light upon this subject from one direction, experiments have been made in which the lime instead of being mixed with the coal prior to heating was used in the form of a separate plug maintained at the same temperature as the coal so that the lime could not influence the coal by direct contact with it, but could exercise, if it were capable of doing so, its effect on the volatile matter expelled from the coal. It was found that the amount of ammonia obtained when the lime was used as a plug was, within experimental limits, the same as when the lime was mixed with the coal. The influence of lime in increasing the ammonia yield was therefore clearly traced to its effect in decomposing volatile nitrogen compounds expelled from the coal and not to an effect in actually expelling nitrogen from the coal in the form of ammonia. Calcium carbonate behaved similarly to lime. Using a plug of oxide of iron, rather more ammonia was obtained than in the absence of the plug up to 600 C, and rather less at and above 800 C, giving the same total ammonia up to 1000 C. In this case the oxide of iron, used as a plug where it could simply act upon the volatile nitrogen compounds, did not lower the ammonia yield from 700 deg upward in the same way as it had done when mixed with the coal in previous experiments.

A noticeable feature in tracing the production of ammonia on heating bituminous coal in nitrogen has been the marked maximum in ammonia evolution which always occurred at 700 C. In order to trace a suspected parallelism in the evolution of gas and ammonia, samples were taken of gas and ammonia at different times during each 100-deg stage of heating, so that, for example, it was known not only how much gas and ammonia had escaped during heating for an hour at 600 or 700 C, but at what rates the gas and ammonia had come off at different times during these one-hour periods. A close parallelism is obtained between the expulsion of ammonia and of carbonization gases (mainly hydrogen), which would suggest that the compounds decomposing in the coal at the maximum rate of decomposition at 700 C yield gas and ammonia at the same time; the two products coming from the same compounds, or compounds so similar that they decompose at the same time. Confirmation for this view was found on repeating the experiments, using anthracite instead of bituminous coal. With anthracite the temperature of maximum evolution of ammonia was higher, being 800 C. The same higher temperature was obtained for maximum gas evolution, and also the same parallelism in gas and ammonia evolution that had been observed for the bituminous coal.

It is not suggested that the compounds decomposing to yield ammonia or gas at 700 C existed as such in the original coal. They have resulted to some extent from the heating process.

Thus even in such a simple compound as glycocoll it has been shown in the (unpublished) work of Monkhouse and Cobb that the expulsion of ammonia on heating follows a somewhat similar course to that described above for coal. The effect of heating is to expel a portion of the nitrogen as ammonia at lower temperatures, but to form also heat-resisting nitrogen compounds which decompose at higher temperatures. (A. H. Eastwood and G. W. Cobb, in Institution Gas Research Fellowship Report, 1930–1931, to the *Institution of Gas Engineers*. Copyright communication no. 40, 31 pp., 17 figs., *e*)

The Effect of Ash on Reactivity and Combustibility of Carbon Materials

IN THE present investigation the experimental method adopted consisted in determining the change of the reactivity or combustibility of carbon when the ash is extracted by acid treatment. To determine whether the measured change in the reactivity could be entirely attributed to the specific action of ash which has been extracted, the authors checked this point in a preliminary experiment in which the change in the surface properties of the carbon due to the ash treatment was determined by measuring the adsorption property of carbon before and after the ash extraction.

The results of this investigation showed that the influence of ash in carbon manifests itself in two separate aspects according to the variety of carbon in question. Thus the reactivity of carbon of coal origin, regardless of the mode of carbonization, is enhanced to a certain extent after the extraction of ash, while carbons from wood, including high- and low-temperature production, markedly decrease in reactivity after the treatment. Referring to the results obtained in the adsorption experiment showing the increased effective carbon surface due to extraction of ash, in cases of both coke and charcoal, it is concluded that the ash in coke behaves as a simple impurity which produces reduction of the effective surface where the reaction takes place, while that in charcoal acts as a catalyst, promoting the reaction strikingly.

The variations of combustibility in air at 900 C were found analogous to those obtained in the case of the reactivity.

Furthermore the combustibility was found to be almost identical for all the carbon materials investigated, particularly so when they are freed from ash, and the marked difference which characterized the reactivity disappeared in this case. It may therefore be stated that the physical factors on the part of carbon have no influence on the combustibility. A slight difference in combustibility in the original sample has therefore to be ascribed to the effect of ash.

Another way in which the ash may affect reactivity and combustibility of carbon is that the ash-forming cinder on the reacting zone retards the diffusion of the reacting gases, whether to or out of the interface. According to the results of the experiment, this sort of action of ash can be observed to a certain extent, while the whole course of the reaction is not seriously affected.

Finally, it is stated that the cause of the two separate and opposed effects of ash on the reactions involving carbon as shown above, may be due to the differences in the chemical and the physical properties of ash in the two varieties of carbon, but it appears that neither the amount nor the composition of the ash is ascribable to this fact. Only the difference in the dispersity of ash, as revealed in X-ray photographs, can explain it; that is to say, the ash in charcoal is distributed throughout in a colloidal dispersity and a remarkable development of the three-phase boundary, carbon-ash-reacting gas, where the catalysis can take place, is attributed to this fact. In the case of coke, however, ash exists largely in a macrostate which causes a considerable reduction of the effective carbon surface, so that the extent of the interface is necessarily small as compared to the amount of ash. (Yoshikiyo Oshima and Yoshitami Fukuda in *The Journal of the Faculty of Engineering*, Tokyo Imperial University, Tokyo, Japan, vol. 20, no. 3, Feb., 1932, pp. 65–99, 26 figs., *e*)

An Investigation of the Action of Coal-Ash Slags on Firebrick by Microscopic Methods

THE purpose of this investigation was to determine the temperature above which rapid attack will occur in the case of a selected series of special refractories and coal-ash slags. It covers an analysis of the behavior of ash slags at various temperatures and explains the mechanism of attack. It is said that when coal ash is maintained in contact with the refractory at temperatures of the boiler furnace, 2200 to 2800 F, the ash generally softens to a more or less fluid condition. If maintained at a given temperature long enough an equilibrium for that temperature will be established between the ash and the refractory, and certain minerals or combination of minerals and glasses will be formed at the expense of the refractory. The mechanism of attack of the slag on the refractories is explained in detail. With certain ashes the range of temperature at which attack takes place is very narrow. For example, with "Peoria ash" at 2375 F very little penetration of ash into refractory is seen, but at 2400 F marked penetration and attack is evident. Large portions of refractory are soon washed out from the face of the refractory and act as nuclei for mullite development.

In the case of some ashes, as Detroit coal ash, the ability to adhere to the refractories seemed to be affected by the character of the refractories. The refractoriness of the various ashes and their behavior were found to be by no means uniform and to vary with the composition of the ashes. With the highly corrosive ashes the mullite development in the refractory appeared to aid in resistance to attack. This was more pronounced with the Peoria and Cahokia ashes; the Kentucky and Missouri refractories showed to better advantage than those from the Pennsylvania field. This variation in mullite development was also noticeable in the differently fired refractories. Mullite developed earlier and in greater amount in refractories fired to cone 12 and cone 14, with the result that a better resistance to the slagging by the more corrosive Peoria, Cahokia, and Chicago ashes was apparent in the cone 12 and cone 14 over the cone 6 refractories.

A slightly greater mullite development was also noticed in the very fine-grind, 16-mesh, over the fine-grind, 6-mesh; here again an improvement in the resistance to slagging with the more corrosive Peoria ash was noticed, but no change was seen in the Chicago and Cahokia ashes. It would appear, therefore, that for highly corrosive ashes that show definite attack around 2350 F it would be highly desirable to use a refractory developing a maximum amount of mullite at these temperatures.

Among the conclusions, only the following can be reported:

Generally speaking, the temperature for serious attack varied as would be expected from the chemical composition and fusibility of the ash; that is, it decreased with increasing influx content and with decreasing softening temperature.

Refractories made by the stiff-mud process showed a somewhat higher temperature for rapid attack then those made by the hand-made or dry-press process.

Although with certain combinations of ash and refractory the temperature for rapid attack could be defined easily within

a range of 50 F, it could not be defined for most combinations more closely than 100 F, and with some extended over an even wider range. This apparent lack of definition is not considered serious, however, for boiler-furnace work where the temperature of a given area cannot be predicted or even, without great care, measured much more closely with assurance than 100 F. (Harold E. Simpson, Ceramic Engr., Battelle Memorial Inst., in a paper before the meeting of the *American Ceramic Society*, Washington, D. C.; abstracted from typewritten original, 28 pp., illustrated, *ep*)

HYDRAULIC ENGINEERING

Large Storm-Water Pumps

SEVERAL interesting features are embodied in the pumps of the new Connors Creek Storm-Water Pumping Station in Detroit, Mich.

Two of these features are the siphon discharges and the method of priming. One of the reasons for the installation of the siphons was the desire to avoid the use of valves, on the discharge side at least. The size of siphon required if a conventional design were to be used was large, and the height made it cumbersome. It was to overcome this latter feature that a lower position of the siphon was selected and an initial method of priming was developed. The operation of priming is accomplished here by first starting the unit and bringing the motor to speed and then operating the vacuum pump until the water in the suction bell reaches the runner. As the air is withdrawn from the siphon the water in the downstream lake rises and overflows into the pump and on to the runner. This method of priming has proved entirely successful. Whether it would work satisfactorily with the centrifugal impeller is not known and is doubted by the authors of the original paper. The principal advantage of it is that it permits the use of a siphon discharge with the low point of the siphon throat just high enough to prevent back flow when the pump is shut down, rather than a siphon with the low point as far above high discharge water as the runner sets above low suction water.

The specifications for the pumps are unusual. It was an early assumption of the consultants, which subsequent experience fully justified, that the accurate measurement of dynamic heads on such large low-head pumps was difficult if not impracticable of accomplishment. The large diameters of suction and discharge nozzles, requiring to be traversed, and the marked irregularities in velocity and pressure distribution across different diameters, introduce problems difficult to meet in a field test. Hence it was decided to define "head" in the specifications as "head of elevation," meaning "the vertical distance between the elevation of the surface of the water in the suction well and the surface of water in the discharge-channel well when the pump under consideration is in operation." This placed the responsibility of correctly estimating the "entrance and exit losses and the loss of head due to friction in the suction and discharge piping" on the pump manufacturer. With a pump required to deliver a given capacity at a special "head of elevation," the pump designer was required to furnish a pump in which the "total dynamic" head must be larger than the "head of elevation" by the estimated amount of the several losses specified. Although this was an unusual obligation to place on the bidder, it was common to all and obviously desirable under the conditions.

The original article contains information as to discharge from the pumps, as to the method of placing the contract, and as to provisions for liquidating damages in the event that guarantees are not met.

The electric power is supplied by the Detroit Edison Co., and synchronous motors operating at unity power factor are employed. The motors are designed for full-voltage starting, which not only reduced the cost of starting equipment but also the size and cost of the primary switch house. (Louis E. Ayres and Geo. E. Lewis, Engineers, Ann Arbor Mich., in *Power*, vol. 75, no. 17, Apr. 26, 1932, pp. 609–613, 6 figs., *d*)

HEATING AND VENTILATION

The Heat Output of Concealed Radiators at Various Temperatures

PRELIMINARY studies of the subject involved a consideration of the method of expressing the results. The heat output of a radiator can be established fairly definitely by the usual procedure of testing with steam or hot water. On the other hand, the object of installing a radiator is to provide heat for a room or building, and this involves not only the supply but also the distribution of heat. Some manufacturers rate their radiators on the first basis and some on the second, and the situation is in urgent need of clarification as, for this reason, it is difficult to compare radiators of different design. The author expresses no opinion as to which method is the better commercially, but comes to the conclusion that the actual radiator output in Btu per hour is the preferable medium for expressing the test results.

Given a definite weight of air leaving the radiator enclosure at a fixed temperature, the supply of heat to the room will be the same whatever type of radiator is inside the enclosure. A number of factors, such as height of ceiling, size and number of windows, may have a considerable influence on the distribution of heated air in the room, thus introducing variables of unknown number and extent into the final results.

A number of radiators of various types were tested. No definite indication was obtained of the features of design that are necessary for obtaining the best results with hot water. It appeared, however, that radiators in which the air passes more than once over a direct heating surface give the highest output ratios. Also the radiators with a dull black finish appear to be better than those left in the bright condition, but the number and variety of experiments are not sufficient to prove this. In the course of the tests the velocities of water and steam through the radiators and the coefficients of heat transmission were respectively calculated. Some of the results are summarized as follows:

The output of a concealed radiator varies with the area of the air inlet, which may be too large to give the best efficiency.

The best form of stack is that with vertical sides. Increasing the area at the top may reduce the output considerably.

The heat output with hot water is usually less than that expected from steam tests. The amount of loss appears to depend more on the disposition of the direct heating surface than on the relative amounts of direct and indirect surface. It may also bear some relation to the finish of the surface, whether bright or dull.

The differences between the temperatures of the direct and indirect heating surfaces were generally less than 1.0 F, except in the case of AY, an unpainted cast-iron radiator, where consistent differences of $1^1/_2$ F to 2 F were observed. It follows that if the direct heating surface is the more efficient this is probably due to the fact that in most cases the air flow is perpendicular to the direct heating surface and parallel to the indirect heating surface.

The coefficient of heat transmission varies considerably in concealed radiators, but generally the higher ratios of hot

water to steam outputs are obtained with the surfaces that are lightly loaded from a heat-transmission standpoint. (E. A. Allcut, Faculty of Applied Science and Engineering Research, in *University of Toronto Bulletin* No. 9, 1932, Section 2, pp. 27–60, 13 figs., *e*)

INTERNAL-COMBUSTION ENGINEERING (See also Mechanics: Vibration Characteristics of Aircraft-Engine Crankshafts)

The Fowler Cavity-Piston Diesel Oil Engine

JOHN FOWLER & CO., of Leeds, England, are building a line of Diesel high-speed oil engines using direct injection. However, a disturbing factor in design has been the so-called "Diesel knock." This characteristic is influenced by the rate of pressure rise on ignition; too rapid ignition causes detonation. During the course of the experimentation conducted by the Fowler company engineers, it was found that this detonation could be materially cut down without affecting efficiency or ease of starting by providing an extra air chamber in the head of the piston, and suitably connecting it to the combustion chamber. In this arrangement, which is known as the Fowler patent air-chamber piston, the quantity of air in the combustion chamber proper is reduced, so that the fuel, when first injected, burns with an insufficient quantity of air, and a resultant retardation in the combustion speed.

Downward motion of the piston is followed, however, by a release of the air stored in the piston chamber, and combustion is continued. This is said to permit higher speeds with clean exhaust and excellent performance. Investigation has shown that no combustion takes place in the piston chamber, so that no carbon deposit is produced therein, nor does the piston overheat. The great turbulence produced by the release of the air from the piston chamber gives very complete combustion, with smooth running and reduced bearing load.

These pistons are of considerable length and made of aluminum alloy. They are fitted with four pressure rings and one scraper ring, and run in cylinders of centrifugally cast cast iron. (*Motive Power*, vol. 3, no. 3, March, 1932, pp. 11–12, 5 figs., *d*)

Turbo-Charging of Diesel Engines

IN THIS paper Alfred J. Buechi, inventor of the process for turbo-charging Diesel engines which has been extensively adopted in the last few years, particularly in the marine field, tells the story of his development. This started with the filing as early as 1905 of a patent on an improvement in the utilization of exhaust gases from internal-combustion engines in exhaust-gas turbines. It was not until 1915, however, that a patent was applied for to cover the idea of fixing the ratio between the power developed in the engine cylinder and that developed in the turbine in such a way that the back pressure of the exhaust in the engine cylinder is lower than the charging pressure adopted. With this arrangement the cylinder walls will not become so hot, which has the effect of allowing an increase in the quantity of charging air. Only by this method can the cylinders be scavenged by precompressed air when the pressure of the latter is higher than that of the exhaust gases. The author gives a description of the actual working processes, and also supplies an equation to express the effective work done by the turbine if it drives only the precompressor. It would appear from this formula after calculation with figures obtained from practice, that even with a very good efficiency of the turbo-blower there is a pressure difference of about 0.02 to 0.05 atm in favor of the charging air. If a cylinder is to be scavenged, certain resistances must be overcome, which means that the precompressed air must attain a pressure considerably in excess of that of the exhaust gas. This is done by lowering the exhaust-gas pressure during the scavenging period, and the mode of operation was so chosen as to obtain a higher pressure before the turbine during the non-scavenging period in order that the mean pressure of the exhaust gas might still be sufficient to give the necessary power to the blower. The mode of operation is therefore such that the pressure before the turbine periodically fluctuates between a maximum during the non-scavenging period and a minimum during the scavenging period, but always so that the power of the gas turbine is as high as possible. After the scavenging period the increase of pressure produced by the next cylinder exhausting is so arranged that it occurs sufficiently late not to influence the scavenging period of the previous cylinder.

In general practice the exhaust turbine in the Buechi process is used to drive the charging compressor. The author shows, however, that it can be used in several other ways. Some of them he does not consider as very promising, others he does. One of these is where the exhaust-gas turbine generates power while the Diesel engine itself only drives the necessary charging pumps. In this case the back pressure with the exhaust-gas turbine must be kept high enough so that the effective work of the Diesel engine is just sufficient to drive the compressor. He considers this method of working especially suitable for very large traction vehicles, and has worked out some special features, so that the temperature before the turbine will be within reasonable and practical limits. This is done by installing a second high-pressure compressor in addition to the charging compressor, and using the air from the second compressor to scavenge the engine cylinders. The total efficiency of this method of working is not expected to be as good as that of a normal turbo-charged Diesel engine, but the method permits driving any machine with the turbine at any desired speed, whether constant or variable. On a locomotive such a system would make it possible to drive at any speed or power without having to use a transmission system. A comparison with other systems of pressure charging is given in the original article, and examples are given of different designs of turbo-charged Diesel engines. It is stated that the output of turbo-charged stationary and marine engines already in service is in excess of 300,000 hp. Data of operation of both air-blast fuel injection and mechanical fuel injection are given. It is stated that in engines equipped with turbo-charging, the life of the valves has been increased and the wear on the cylinder linings has been found small. The blades in the turbines do not suffer, and a reduction in fuel consumption and in consumption of lubricating oil has been obtained. (Paper before the Kikai, Gakkai, and Zosen Kyokai Society, Tokyo and Osaka Meeting, May 29 and June 10, 1931, by Alfred J. Buechi, abstracted from a privately printed abridgment, 28 pp., 38 figs., *dh*)

The Rupa Coal-Dust Engine

THE Rupa engine is a Diesel engine capable of operating on solid powdered fuels, such as coal dust. The distinctive features reside in the fuel-injection equipment and the lubricating arrangements, and substantially the only extra first cost of the engine as compared with the Diesel is in respect to the special cylinder-head attachment.

Referring to Fig. 2, the main piston 1, as it descends, draws in air through the valve 2 in the cylinder head 3. The latter is provided with a special fuel head and antechamber 4, in place of the fuel-injection nozzle of a Diesel engine. The chamber 4 is permanently open to the main cylinder through the nozzle 5.

Powdered coal in the hopper 6 is drawn into the antechamber during the suction stroke of the main piston through the double valve 7, 8, but owing to the length of the chamber 4, and the special form of the aperture 5, no appreciable quantity of fuel enters the working cylinder during this stroke.

The double valve 8, 7 closes, in this sequence, when the valve 2 closes at the end of the suction stroke. During the compression stroke, the air in the main cylinder is compressed to about 32 atm and 430 C. The air in the antechamber reaches nearly the same pressure and temperature, and part of the fuel there in suspension is thus ignited without any special ignition device. The oxygen available in the antechamber suffices only for the combustion of from 8 to 10 per cent of the fuel present, but this degree of combustion is effected almost instantly. As a result an excess pressure of from 30 to 60 atm is developed in the antechamber, and the remainder of the fuel, already thoroughly preheated, is expelled into the main cylinder where it burns in the ordinary way. The charging of the antechamber during the suction stroke of the main piston is an essential feature of the cycle.

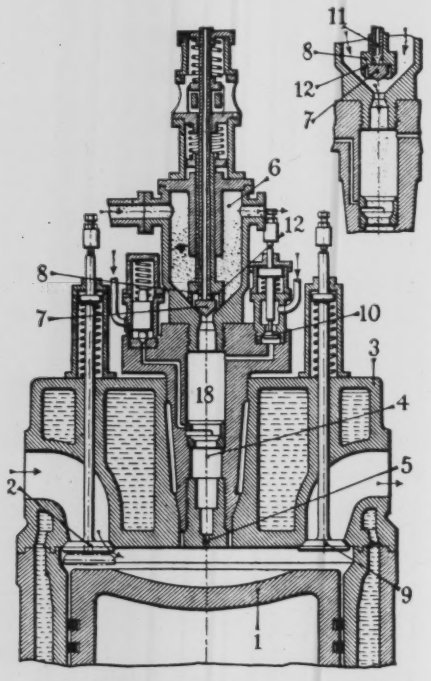

FIG. 2 (LOWER LEFT) CYLINDER HEAD SHOWING VALVES, ANTECHAMBER, AND FUEL HOPPER

FIG. 3 (UPPER RIGHT) DOUBLE FUEL-INJECTION VALVE

The exhaust valve 9 opens immediately before the lower dead center is reached on the working stroke. By this time the suspended particles of coal have been burnt to suspended particles of ash, most of which are carried out by the exhaust gases.

The details of the double fuel-admission valve 7, 8 can be seen in Fig. 3. The space between the two valves is connected to the open air 11 by two inclined openings 12, which are automatically controlled by the motion of the inner valve 7.

The engine is started by compressed air. The cylinder cover and antechamber are water cooled as in Diesel engines. The cooling of the piston depends on the size. Each piston is lubricated by oil pipes taken through the water jacket and cylinder lining, a separate water plunger being provided for each pipe. The function of the copious oil supply is to wash out ash deposits, as well as lubricate the piston. Sludge pipes are therefore provided between the oil admission pipes to carry out oil and ash to a settling tank and filter.

A full account of trials on several Rupa engines of different sizes is given in a report by Francesco Roma published in *Il Calore*, December, 1931. (*The Power Engineer*, vol. 27, no. 312, March, 1932, pp. 85–88 and 114, *d*)

LUBRICATION

Bearing Lubrication

THIS paper is a synopsis of the results obtained from experiments carried out on an oil-ring bearing. The machine itself was described in the *Journal* in 1931, on p. 490 and following. Briefly it consists of a ring-oiler bearing 5 in. long and a load carriage mounted on a $2^1/_2$-in. shaft. The bearing pressure can be varied by adding or removing weights, and the machine can be driven in either direction by means of a variable gear. The bearing is of the double-ring-oiler type, but as the load is applied on the top of the bush the slits for the oil rings are on the loaded side of the bars. This is rather a serious defect as the oil is fed to the journal at the point of maximum pressure. One of the most interesting features of the machine as now installed is an optical device (described in the original article) for measuring the thickness of the oil film.

In the course of the tests, sets of temperature-coefficient-of-friction curves for various bearing pressures were obtained. From this it would appear that at speeds above 44 rpm the value of the coefficient of friction decreases due to the decreased viscosity of the oil with rise in temperature. The variation of the coefficient of friction with temperature is discussed in detail in the original article, particularly at the start.

It is claimed that the friction results obtained are very consistent. In the friction tests the experimental values of the coefficient of friction appear to be rather large for conditions of pure fluid friction, and an attempt is made to explain this phenomenon. The machine proved unsuitable for eccentricity and attitude determinations. A series of tests were made on three different machines, one of which, the Boult, was used for an endurance test of the oils.

It would be difficult from the foregoing tests to say which was the best oil, as no one oil comes out best in all tests. The selection of the oil will depend on the conditions of operation such as load, speed, and temperature.

Thus for moderate loads, oil No. 3 or No. 2 might be used, the preference being given to No. 2 because of its greater oiliness, if there was the possibility of much service under conditions of boundary lubrication. On the other hand, preference might be given to No. 3 on account of its low pour point, if there was the possibility of low temperature (say, 12 F) being encountered. Also oil No. 3 has the least decrease in oiliness after use of all four oils.

For conditions of high load and normal temperature with the possibility of some service under conditions of boundary lubrication, oil No. 1 might be used owing to its high viscosity and good oiliness factor. On the other hand, its decrease in oiliness after use is the greatest of all four oils.

Again, for conditions of high load with the possibility of low temperature, oil No. 4 might be used, due to its high viscosity and low pour-point temperature. Also, of the four oils, No. 4 has the second lowest decrease in oiliness with use.

The preceding tests, while they give the general characteristics, cannot be taken as indicating conclusively which is the best oil, as it may be only after months of use that the real value of a lubricant becomes apparent. The friction-reducing ability may be of less importance than such properties as ability to withstand oxidation, emulsification, etc.

Long-period tests on these oils have still to be carried out, and these may reveal different characteristics.

The characteristics of the four oils referred to in these conclusions are given in the original article, which does not, however, indicate the origin of the oils. (A. S. T. Thomson in *The Journal of the Royal Technical College*, vol. 2, part 4, Jan., 1932, pp. 638–656, 12 figs., *eA*)

MACHINE PARTS

A Swivel Caster

IN A CASTER now being manufactured by Divine Bros. Co., Utica, N. Y., the rigid king pin is replaced by a flexible ball joint (*B*), Fig. 4, seated on the hardened cup of a Dardelet self-locking safety set screw. The raceways are held together by the simple method of splitting them vertically instead of horizontally (*A* and *C*). By this balanced assembly, the load is distributed on center and annular balls, approximately two-thirds on the former and one-third on the latter. Each ball supports an equal portion of the load and resists an equal share of the thrust. The axle of the caster rides on Hyatt automotive-type roller bearings, operating in a Hyatt split outer race. (Abstracted from a news release by the manufacturer, issued in April, 1932, *d*)

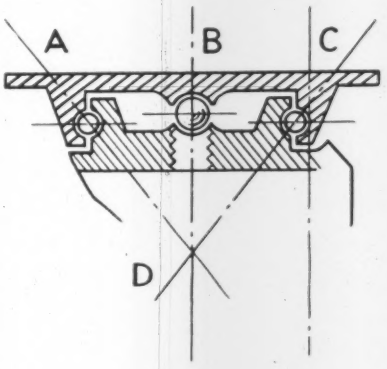

FIG. 4 THE TONWATE SWIVEL CASTER

Use of the Micropyrometer for High-Temperature Melting-Point Investigations

THIS paper discusses the phenomenon of melting generally, and describes an apparatus which has been developed at the Pittsburgh Experiment Station of the United States Bureau of Mines for determining the point of fusion. (A very similar apparatus, the de Graaf, was designed and placed on the market for commercial use almost simultaneously with the development of the apparatus by the Bureau of Mines.)

A special definition of melting point is required for the method, since the determination of that property depends upon the observation of the operator. The definition which was selected is: The melting point of an irregularly shaped refractory particle is that temperature at which the viscosity (or crystalline rigidity) is overcome by the random motion of the molecules, and at which the surface tension is sufficient to draw the particle into a globular shape.

The reasons leading to this selection and a critical survey of other definitions of the melting point are given in the paper.

The method is very accurate for the determination of the melting points of stable compounds, eutectics, and pure oxides. It can be used for materials which present insurmountable refractory and atmospheric difficulties to other more widely known procedures. Quite satisfactory results have been obtained for such materials as the high FeO ferrous silicates, and the high MnO manganous silicates, and in the authors' opinion there is no other method which has been developed to date which will give as reliable check results on these materials. The accuracy of the method is admittedly decreased in the study of materials which have wide temperature ranges of solid-liquid immiscibility. (G. R. Fitterer and M. B. Royer, Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa., in Report of Investigations, Department of Commerce, Bureau of Mines, R. I. 3151, March, 1932, mimeographed paper, 14 pp., illustrated, bibliography, pp. 15–17, *de*)

MACHINE TOOLS

Designing Skiving Tools for Formed Parts

THE skiving or undercutting tool is a forming tool fed into the work tangentially. The contour of the cutting edge is not the same as a true contour of the product and lies in a plane set at two different angles. This allows the points of the cutting edge to come into action consecutively—that is, the work is finished to size at one end as soon as the point of the tool at *O*, Fig. 5, passes the center line of the work. The finishing size then continues along the work, the entire length being turned when *A* passes the center line.

The true form of the product appears nowhere on the skiving tool, and a corrected contour is required for the cutter employed to form the tool. The true form may be found, however, when

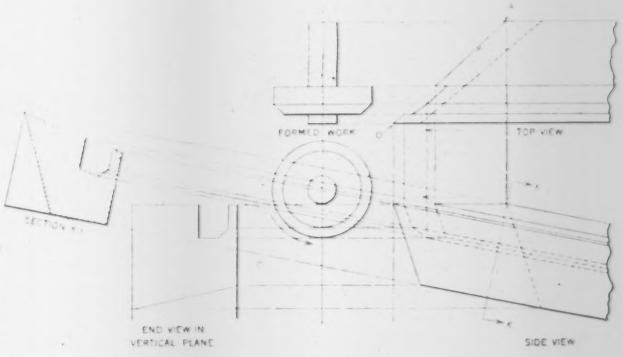

FIG. 5 SKIVING TOOL FOR FINISHING FORMED WORK BY EMPLOYING A TANGENTIAL FEED MOVEMENT

the tool is in the cutting position by projecting all points of the cutting edge perpendicularly on a vertical plan that is parallel to the center line of the product, as in Fig. 5. This corrected contour is not always produced accurately on the tool, and hence there is an adjustment on the machine for tipping the tool sidewise to minimize the error. However, this adjustment of a wrongly constructed tool never gives a perfect product, as when adjusted for horizontal surfaces it is off the vertical surfaces, and vice versa.

The article gives in detail instructions for obtaining the position of a skiving tool and rules for laying out skiving tools, as well as the method of computing the data necessary for locating the points of the contour, which can be done either geometrically by projection or analytically. The author believes that this is the first time that a complete treatise dealing with the subject of skiving tools has been presented. (James L. Ingalls, Ingalls' Engineering Service, Springdale, Conn., in *Machinery*, New York, vol. 38, no. 7, March, 1932, pp. 507–511, 6 figs., *dA*)

MEASURING INSTRUMENTS (See Engineering Materials: Illium—A Metal for Instruments)

MECHANICS

Vibration Characteristics of Aircraft-Engine Crankshafts

THE tests described in this paper were made to develop a satisfactory instrument for recording torsional vibrations and to make possible the calculation of frequency of vibration from drawings.

Troubles observed from crankshaft vibration are first dis-

cussed. Many types of instruments suitable for recording the vibrations were considered and discarded. It was decided that the desired instrument should draw a graph of torsional displacement against time. Two such instruments are specially referred to. One was developed by Dr. H. Thoma, of Karlsruhe, Germany. The novel feature of this instrument was the use of toothed condenser plates, one attached to the crankshaft and the other to a uniformly rotating member. The variations of capacity of this condenser were used, as in the condenser microphone, to modulate a vacuum-tube circuit, the plate current of which passed through an oscillograph. This arrangement is capable of being calibrated and gives a displacement-time record. Another device which has been used successfully is Dr. Geiger's well-known torsiograph. It was by means of these instruments that the failures of the power plants on the *Graf Zeppelin* were analyzed.

An early design of torsiometer used by the Matériel Division incorporated links and pins to impart motion to an indicating hand. The latter moved over a scale graduated in degrees and was read by means of a neon stroboscope. Rapid wear proved to be fatal to this type of instrument, in spite of case-hardened parts. In the spring of 1928 the idea occurred to the author that a flexible cable of small size could be used, and this was accordingly incorporated in the instrument used during the summer of 1928. The arrangement makes use of pulleys and a drum on the shaft carrying the pencil. This has proved very successful and is quite free of backlash. The cable eventually wears out but is readily replaced, and, under the severest conditions so far met with, the life of the cable is several hours of continuous operation. The record is made on ordinary indicator paper. A drum is provided which retains the paper, and since the pencil revolves with the instrument, the drum is held in the hand, inserted over the pilot provided for it, and quickly pressed in and withdrawn. The last one-thirty-second inch of motion of the drum operates a bellcrank system and presses the pencil against the paper. A pointer is provided on the drum, and with the engine set on top center of one cylinder the beginning of the card is lined up with the pencil, the pointer being vertical. This serves to locate the crank positions on the records. The two revolutions in the engine cycle are superposed, hence the complete cycle crosses the card twice before it repeats. In the present design the records show a displacement of one-eighth inch for each degree of torsional displacement of the crankshaft. The natural frequency of the spring-driven flywheel is 10 to 12 vibrations per second. This frequency is necessitated by the high accelerations to which aircraft engines are subjected.

A number of records from various engines are presented in the original paper, after which a method is described for calculating the frequency of torsional vibration in aircraft engines, including those of the radial type. (F. L. Prescott, Matériel Division, Air Corps, Wright Field, Dayton, Ohio, in *Air Corps Information Circular*, vol. 7, no. 664, Power Plant Branch Report, Feb. 22, 1932, Air Corps Technical Report no. 3533, 20 pp., 23 figs., *ed*)

METALLURGY

Hardening of Steel by Quenching in Pectin Solutions

THIS invention relates to improvements in the hardening of steels and alloy steels which are capable of hardening on quenching—for example, chrome steel, nickel steel, silicon steel, and tungsten steel. The inventors state that they have ascertained that the heat conductivity of pectin solutions is approximately the same as that of oils, which latter are particularly suitable for the hardening of steel. Based on these facts, the hardening of steels with pectin solutions and pectin extracts has been investigated, and it has been found that these exhibit outstanding advantages for this purpose. Thus, it has been found possible to obtain varying results, according to the concentration of the pectin solution, so that, depending upon the concentration of the pectin solution employed, various degrees of hardness, tenacity, and brittleness of the hardened steel can be obtained. Accordingly the process of hardening is characterized in that solutions of pectin materials or of like plant colloids are used as hardening agents. These pectin substances or like plant colloids are colloidal chemical compounds of vegetable origin, which are chiefly obtained from the cell walls of plants, such as fruits and sugar beets. The pectin solutions employed according to this invention offer, as compared with steel-hardening oils, the advantage of accurate adjustability. Oil, as is known, is immiscible with water, whereas mixtures of water and pectin can be prepared in any desired proportions. A further advantage is that oil is combustible, while pectin solutions are not. Since the steel is generally introduced into the hardening bath in a glowing condition, this fact is of special importance. The most important advantage is, however, the low price of the pectin solutions, which are many times cheaper than hardening oils. Yet another advantage of the process of the invention is that the hardening and tempering, which have hitherto been effected in two separate operations, can, by a suitable regulation of the concentration of the pectin solution, be carried out in one operation. For the hardening of steels pectin solutions of 0.5 to 15 per cent and over can be used. Instead of artificial pectin solutions, natural pectin extracts, derived from portions of plants, which can be concentrated or diluted as desired, can be used. When it is desired to obtain high brittleness and hardness, solutions with small pectin content are used. When, however, a steel of high tenacity and low hardness is desired, higher concentrations are used. The desired hardening effect must be exactly determined by empirical means, depending on the composition of the steel, For example, for tool steel, which should show great hardness but be as tough as possible, about 4 per cent pectin solution is used. The concentrations of the pectin solutions hereinbefore mentioned are expressed as percentages of dry soluble pectin substance in the solution. (British patent to the Pomosin Werke, of Frankfort, Germany, no. 367,630, Feb. 25, 1932; abstracted through *The Engineer*, vol. 153, no. 3978, April 8, 1932, p. 410, *d*)

POWER-PLANT ENGINEERING (See Engineering Materials: The Mercury Industry in 1931)

RAILROAD ENGINEERING

A 93-Mile-an-Hour Rail Car

A DOUBLE passenger car, over 137 ft long, with its own motors and capable of a sustained speed of over 93 mph, will be placed in service between Berlin and Hamburg some time in the coming summer. With the going into effect of the summer schedule, the maximum speed of the regular "FD" (non-stop) trains on the same stretch will also be increased from the present $68\frac{1}{3}$ mph to $74\frac{1}{2}$ mph. This has been made possible by increasing the distance from the first cautionary signal to the final signal from 700 to 1200 meters, thus giving the brakes time to act.

The new motorized car will be rounded at each end to reduce atmospheric resistance. The most favorable form was

determined by experiments with models in the wind tunnel of the Zeppelin works at Friedrichshafen. The new car, half of which will be for smokers, will have seats for 102 second-class passengers. A small refreshment room will be added in the middle, in which hot and cold drinks and cold food will be served. (*German-American Commerce Bulletin*, published by Board of Trade for German American Commerce, New York City, vol. 7, no. 3, March, 1932 p. 10, *d*)

STEAM ENGINEERING

Methods of Improving the Efficiency of Steam-Turbine Blades

THE author determines experimentally the absolute value of steam friction on the concave side of steam-turbine blades and shows that at one atmosphere absolute pressure it is very small. From this he draws the conclusion that there must be other factors which are responsible for the reduction of efficiency in the operation of these blades. He thinks that the cause of low efficiency lies in the usually high compression of the steam on the concave side of the blade, and outlines certain methods for improving this efficiency. The average compression pressure p_m in kg per sq cm in the case of a steam-turbine blade is computed by dividing the peripheral force p_u in kg by the projected blade area f, or

$$p_m = \frac{p_u}{f} = \frac{m\Sigma c_u}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where m is mass of steam per blade per second in $\frac{\text{kg.} \times \text{sec.}}{\text{m.}}$

Σc_u is the sum of the velocity components in the peripheral direction in meters per second, and f is the projected blade area in square centimeters.

If the compression pressure is known, the fall of compression i_v can be found from the i-S diagram for the given turbine stage.

The average i_v or the average compression pressure p_m can, according to Equation [1], be reduced by the following three methods:

a By reducing the mass of steam per blade per second, which, in turn, can be done (1) by reducing the angle of the nozzle and (2) by reducing the spacing of the blades;

b By increasing the width of the blade, and

c By reducing the sum of the velocity components Σc_u.

Reduction of the Angle of the Nozzle has been successfully employed in recent years. By this means the factor Σc_u is somewhat increased and the efficiency raised thereby. Indirectly, however, the improvement in efficiency is obtained by the reduction of the average compression pressure. The mass of steam per blade, and hence approximately the average compression pressure, falls off in proportion to the sine of the angle of the nozzle. Of course, the angle of the nozzle cannot be reduced indefinitely, and the lowest limit is somewhere around 10 deg. Furthermore a reduction of the angle of the nozzle is not necessarily an advantage, as it produces an increase in the angle of reversing of the blade.

Experiments made hitherto in an attempt to reduce the spacing of the blades have been unsuccessful. There is here a lower limit, and with further decrease of spacing the edge shocks increase, and finally the friction of the steam against the walls, which usually is quite small, may become of material importance.

Increasing the Blade Width. Experimental data on blade losses as a function of blade width are very contradictory. Bánki has obtained a material improvement by using blades from 52 to 81 mm (2.04 to 3.18 in.) wide as compared with 25 mm (0.98 in.), while Rateau found quite to the contrary. Rateau, simultaneously with increasing the width of the blades, increased in the same proportion the spacing of the blades, so that he reduced the compression pressure on the one hand and increased it on the other. The author's experiments agree with the results obtained by Bánki. The author has varied both the width and the spacing, and obtained the best results with the widest blades (81 mm = 3.18 in.) and a comparatively very small spacing. Wall friction seems to have been of very little importance; this has already been shown by previous experimenters, but the author confirmed it by measuring absolute values.

The average compression pressure, which is considered to be the main source of losses in the rotor blades, is naturally small where the width of the blades is great and the spacing comparatively small. With an increase in the width of the blades the radius of curvature increases likewise, and this can be only of favorable import; simultaneously with this the edge shock losses decrease as fewer blades are used. It would therefor appear that an increase in the width of the blades is one of the most important devices for decreasing the losses in rotor blades.

Reduction of Σc_u. This may be considered a further factor in reducing the average compression pressure. This can be done either through a selection of a high value of the ratio u/c, and, for example, in impulse turbines $u/c = 0.5$. This in itself raises the efficiency and in addition indirectly brings about the same results through reduction of the average compression pressure. It is also possible to reduce Σc_u through a decrease in loss of head per stage, i.e., employment of multi-stage turbines, a procedure which is known to be very effective. It is remarkable that more attention was not paid long ago to the simple matter of magnitudes of average compression pressure and average fall of compression. Had this been done, better turbines would have been built at an earlier date.

The next question that might be considered is how reduction of the average pressure per unit area or average compression fall affects the first cost of steam turbines. The cheapest method to employ is that of reducing the nozzle angle. This can be particularly usefully employed in the high-pressure stage. The reduction of spacing causes a very small increase in first cost, but it soon reaches a possible limit of its application. Employment of wider blade profiles results in a greater expenditure of money, but the greatest cost is caused by the decrease in head per stage, i.e., employment of multi-stage turbines. It is, however, not unlikely that by the application of wider rotor blades and higher steam velocities the desired economic construction of steam turbines may be effected.

The foregoing considerations apply primarily to impulse turbines, but the same principles may be considered in connection with reaction turbines. In the latter, as a rule, very low heads of compression are used today, and in accordance with what has been said above, very high efficiencies would be obtained from them if only the radial leakage losses common to reaction turbines did not reduce the efficiency to such an extent. All the tests have been made in the steam range of 1 atmos. abs. pressure, corresponding to the average working range of a condensing turbine.

In the course of the experiments, measurements were made on the friction of a helicoidal jet of steam flowing through a hollow cylinder, and a formula has been derived to express the loss of velocity due to the flow of steam through a hollow cylinder as a result of wall friction. (F. Burghauser in *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 3, no. 2, edition A, pp. 83–86, 2 figs., *et*)

TESTING AND MEASUREMENTS

An Endurance-Testing Machine for Belts

THIS machine was invented by Prof. C. A. Norman, of the Ohio State University, Columbus, Ohio, and is designed to test the life of a belt in a reasonable number of hours. This is done by the use of a differential drive in which one belt acts as a brake on another and absorbs all the power transmitted by it. The machine is so arranged that the belts may be subjected to all the effects which influence their life in actual power transmission, such as the slip which causes surface wear and heating, the flexing over the pulleys which causes internal strains and wear, and the difference in tension between the slack and the tight sides which leads to stretching, fatigue, and internal deterioration. The methods of measuring the various factors are briefly described. If desired, the two test belts can be enclosed in a stove or heater in order to study the effect of temperature on their life. Manufacturers of rubber belts, which latter are very sensitive to overheating, have secured valuable data from tests carried out under such conditions. The machine may be used for selecting pulley material, testing belt fasteners, etc. (C. Norman Fletcher in *Mechanical World*, vol. 91, no. 2355, Feb. 19, 1932, p. 173, *d*)

Accelerated Test for the Determination of the Limiting Creep Stress of Metals

IT IS CLAIMED that one of the greatest handicaps to progress in the development of improved heat-resisting materials is the difficulty of obtaining reliable data concerning the ability of metals to carry stresses without deformation at high temperature. This difficulty arises owing to the change from a condition of elasticity as ordinarily understood to a state of viscous flow whereby continuous deformation or creep may proceed at very small rates.

The accelerated creep test described in the present paper depends on the measurement of the diminishing rate of creep in a stressed test piece by means of a steel weigh-bar so that the creep of the test piece is accompanied by a proportionate decrease of the applied stress. In the apparatus diagrammatically shown in the paper a test piece 6 in. long and 0.25 in. in diameter is heated by means of a resistance-wound furnace 24 in. long, the winding of which is made close at each end of the tube so that the variation of temperature along the test piece does not exceed 2 C. Stress is applied by turning a screw, and the actual stress on the test piece is known from the extension of the weigh-bar. Should any creep take place in the test piece, this is immediately indicated by a decrease in stress as shown by the extensometer, which latter consists of an Ames dial gage in conjunction with a simple lever device.

Consider a test piece stressed to 14 tons per sq in., say, at 500 C, well within the creep range; the test piece creeps fairly rapidly at first, and there is a corresponding rapid decrease in stress. As the stress decreases, the rate of creep diminishes, and a curve is obtained. If a new test piece is stressed, at the same temperature, to the remanent stress of the preceding test, it is found that it shows an initial rapid decrease in stress, which, however, takes place at a lesser rate than the initial stress decrease in the preceding test. Curves at still lower initial stresses show a decrease in stress, but at a correspondingly decreasing rate.

After carrying out a preliminary series of tests along these lines, it was found that the initial stress was approximately proportional to the decrease in stress in a given time. Hence, by plotting the decrease in stress against the initial stress, the straight line drawn through the points, if produced, cuts the initial-stress axis at a certain value representing the stress which will give no measurable decrease in stress in the period of the test. As elsewhere explained, this must correspond to a total creep of less than 7×10^{-6} in. per in. for the period of test. After numerous experiments it was found that a period of 48 hr gave the best combination of accuracy of limited test duration. It was also found in the present test that for any given conditions of temperature and initial stress the rate of decrease in stress in tons per square inch will depend upon the dimensions of the test piece.

The original paper contains interesting data on a comparison between tests made by the method here described and one tested elsewhere by a different method. The evidence afforded by the comparative tests leads the authors to believe that the limiting stresses obtained by their method of testing approximate closely to safe stresses, i.e., stresses which give negligible initial deformation and permanence of dimensions for long life. (Paper before the Institution of Mechanical Engineers, Feb. 19, 1932, by W. Barr and W. E. Bardgett; abstracted through *The Engineer*, vol. 153, no. 3972, Feb. 26, 1932, pp. 241–242, 7 figs., and 3 tables, *ed*)

Testing the Zinc Coating on Galvanized Wires

THE British Standards Institution has just issued specification No. 443 bearing the above title. The standard test adopted is the copper sulphide dipping test. The question of alternative tests was fully discussed and the conclusion reached was that the data in existence regarding other methods of testing were insufficient to justify their inclusion in a standard specification. This applies, among others, to the salt-spray test. As regards the mandrel or wrapping test, a modification has been adopted. Experience has shown that very soft qualities of steel such as are used for galvanized line wire for telephone and telegraph purposes, do not, under ordinary methods of galvanizing, take up such an adherent coat as rather harder qualities; hence, for these qualities the diameter of the mandrel has been specified at eight times and for all other qualities four times that of the wire.

Some difficulty has also been experienced in the past in defining a criterion for rejection of wires which have been subjected to a wrapping test. If the coat definitely flakes and peels off there is no doubt as to the defective character of the galvanizing; but if it is stated that after wrapping there should be no cracks in the coat, arguments may arise as to exactly what constitutes a crack. Wrapped samples were examined by the Committee, and a divergence of opinion was found as to whether some of the samples exhibited cracks sufficient to merit rejection or not. This difficulty was therefore overcome by specifying that the wrapped samples should be unwrapped and then subjected to a copper sulphate dipping test of slightly reduced severity. This dipping test therefore acts as an indicator as to whether the coat has been materially damaged by the ductility test imposed upon it, and leaves no room for argument as to whether the wire has successfully stood the wrapping test or not. (Lt-Com. Geoffrey K. Rylands in *The Engineer*, vol 153, no. 3980, April 22, 1932, p. 445, *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

SYNOPSES OF A.S.M.E. PAPERS

THE papers abstracted on this and following page appear in the current issues of the Aeronautical Engineering, Oil and Gas Power, and Petroleum sections of A.S.M.E. Transactions, or are available on request in mimeographed form. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering." Copies of the Transactions papers may be obtained by those not registered in these Divisions by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

AERONAUTICAL ENGINEERING

Transmission of Visible, Infra-Red, and Ultra-Violet Radiation Through Fog

FOG menaces all forms of transportation, particularly air travel. To study the visibility of beacons through fog, a laboratory method of producing fog was developed. Fogs of two types have been made with a range of densities corresponding to natural fogs in which the visibility varies from 20 ft to 2000 ft. Transmission of radiation through these fogs has been measured, covering a wave-length range of 0.30 to 0.40 micron in the ultra-violet, 0.40 to 0.75 micron in the visible, and 0.75 to 2.6 microns in the infra-red parts of the spectrum. The conclusion is that the penetration of infra-red through fog is many times that of visible light, the ratio depending upon the distance and the nature of the fog, and consequently infra-red gives promise in developing aids for fog landing, especially in localizing a fog-obscured airport. (Paper No. AER-54-1, by S. Herbert Anderson.)

A Radio System for Flying and Landing Aircraft in Fog

WHILE scheduled air transportation has been immeasurably aided by the provision of radio-direction facilities on the fixed airways, interruption of scheduled flying is still the rule whenever the landing field lies in an area completely enclosed by fog. The results secured by the development of instrument flying and of radio navigational aids to point-to-point flying are then nullified through the lack of means for safe landing under adverse conditions of visibility. The rigorous maintenance of scheduled flying by day or night requires the removal of this last great hazard to the reliability of air travel and transportation. This paper describes a radio system of blind landing aids, developed by the Aeronautics Research Division of the Department of Commerce at the National Bureau of Standards, which gives good promise for the solution of this difficult problem. The results already obtained with this system indicate that it will soon be ready for use under the severe conditions encountered in commercial air transportation. The system has been developed to be adaptable for use in conjunction with the radio navigational aids already being provided for point-to-point flying on the civil airways of the United States, and for this reason requires a minimum of additional equipment both on the ground and on the airplane. (Paper No. AER-54-2, by H. Diamond and F. W. Dunmore.)

General Maintenance and Suggestions for Lowering Overhead

WHEN an airplane crashes, it is easy to set fire to it and write it off as a loss, but the author contends that half of the wrecked planes, except where they have been badly burned, may be salvaged and rebuilt. He gives many details of where and how this may be done. The value of constant inspection is emphasized, and the paper describes in detail many points sometimes overlooked. Special tools for difficult repair jobs are outlined. (Paper No. AER-54-3, by H. C. Downey.)

The Ice Hazard on Airplanes

THE problem of the formation of ice on airplane wings and propeller blades and of its prevention or quick removal is discussed in this paper. The most practical device for the removal of ice on the leading edges of airplane parts is asserted to be a rubber overshoe capable of being inflated and deflated with an air pump at the rate of three times a minute. A special oil mixture applied to the rubber lowers its ability to adhere to ice. The removal of ice from propeller blades has not been successfully demonstrated. (Paper No. AER-54-4, by William C. Gear.)

Wing-Radiator Development

THIS general paper on the subject of wing radiators contains a summary of experimental data of the Curtiss company and information on much original work. It should be of interest and help to airplane designers. The author explains apparently contradictory results by referring to details of the comparatively few installations of this type and the usual accompanying secrecy. The use of wing radiators for general service is questionable, as they are expensive to build and easily subject to damage. (Paper No. AER-54-5, by G. A. Luburg.)

Supercharging the Airplane Engine and Increasing Speed With Altitude

ON LONGER distances a high cruising speed is a necessity. As the speed increases with the cube root of the horsepower, high-speed transportation would not be economical. Flying at higher altitudes with supercharged engines would greatly increase the efficiency. A simple mathematical equation for close estimation of the increased speed in altitude is developed, and the merits of the size of an efficient plane are discussed. (Paper No. AER-54-6, by Robert J. Nebesar.)

Single-Blade Windmill for Electric Generation

A WINDMILL with a single blade, counterbalanced, is described that may be used for generating electricity for lighting farms, airway beacons at remote points, refrigeration, deep-well pumping, etc. The generator is mounted on the windmill shaft, and with the assistance of a storage battery, a constant supply of electricity is made available, even though there may be a failure for several successive days of a wind of the required velocity. (Mimeographed paper, by E. N. Fales.)

FUELS AND STEAM POWER

Problems in Utilizing Bunker "C" Fuel Oil, With Special Emphasis on Oils Containing Cracked Residues From High-Pressure Stills

THIS paper describes some typical operating experiences observed during the last few years in the burning of Bunker "C" fuel oil, which were sufficiently exceptional, and sometimes so expensive as to warrant the attention of those interested in the art. It is confined to plants equipped with burners of the pressure or mechanical atomizing type, as the author knows of no cases where exceptional difficulty has been experienced with steam atomizing burners using similar fuel. The extended discussion supplementing the paper presents the results of much varied and practical experience. (Mimeographed paper, by T. B. Stillman.)

OIL AND GAS POWER

Gear Drives for Motorships

THIS paper has been written with the object of clarifying a much misunderstood situation. While the conclusions arrived at represent the author's own deductions from current accomplishments, they are based on known facts and data, and other authorities are quoted extensively in order to present unbiased view from engineers who have no direct interest in the production of any particular type of engine and to avoid the impression of a one-man idea. Where opportunity has permitted it, reliable data have been quoted; where not so permissible, data have been omitted. It is suggested that the bibliography appended to the paper be carefully consulted in order that the scope of this effort may be fully digested. (Paper No. OGP-54-2, by J. Barraja-Frauenfelder.)

PETROLEUM MECHANICAL ENGINEERING

Repairing Oil Trunk Lines by Arc Welding

REPAIRS to oil trunk lines should be made in the field without interruption to the service, and the methods of fixing up split joints, leaking couplings, and line breaks by the use of arc welding are described. Pipe line that has been corroded or that has become badly pitted also is patched and repaired by this means. Data are given to show that patch welding pays. (Paper No. PME-53-5, by Albert N. Horne.)

Evaluation of Steam-Turbine Oil Stability

THE Navy work-factor method, although sufficient in itself to indicate the rate of decomposition, loss through evaporation, and the corrosive tendencies in steam-turbine oils, fails to measure definitely the resistance to emulsion. Considering demulsibility at 130 F of samples taken every 25 hr during the 100-hr Navy work-factor run, however, the emulsion tendencies are recorded, and this demulsibility change is a measure of the stability of steam-turbine oils. (Paper No. PME-53-6a, by C. M. Larson.)

The Work Factor of Lubricating Oil

THE usefulness of the standard laboratory tests in judging the quality of lubricating oils in the past has been limited, due to widely different crudes from which lubricating oils are produced and to the varied processes used in their refinements. The new method proposed for evaluating lubricating oils seeks to extend the application of the standard laboratory tests in that their results will indicate the service that will be obtained from the oils in actual operation. Increases in viscosity, neutralization number, precipitation number, and per cent of carbon residue of a lubricating oil when subjected to an endurance test, which simulates service conditions as found in a forced-feed lubrication system, are expressed numerically by means of formulas, and the average of these results is called the work factor of the oil. A description of the method and apparatus of the endurance test is given, and the concordance of results obtained is shown when different machines are used to test the same oil. The work factors of turbine, Diesel-engine, and aviation oils are discussed with relation to their performance in actual service. The Navy method for purchase of lubricating oils, employing the work factor, is discussed, as also are the advantages derived from the use of the work factor (Paper No. PME-53-6b, by James G. O'Neill.)

Stresses in Dished Heads of Pressure Vessels

THIS paper develops the problem of the proper profile for the dished heads of pressure vessels. The author's company uses large drums for high internal pressures. The results are given of tests made over a period of several years on these drums in which strain-gage readings were taken. The bending stresses therein are more critical than the meridional-loop stresses. (Paper No. PME-53-7, by Cyril O. Rhys.)

TEXTILES

Control of Picker-Room Humidity

THIS paper attempts to deal with the subject in a non-technical manner. The control of the amount of moisture in cotton laps delivered to the card room is highly desirable. Cotton manufacturers desire uniform weights for any given unit of length from the ounces per yard of picker laps to the grains per hank in the final yarn. If laps delivered to the card room contain widely varying percentages of moisture, though a lap scale may indicate identical gross weights, a variation in weight per yard is immediately begun at the cards which must be corrected by gear changes in subsequent operations. By holding picker laps to very close limits as to the net weight of cotton contained for the same number of yards of lap produced, the beginning of evenness or the elimination of variation in subsequent operations is attained. (Paper No. TEX-53-1, by Norman E. Elsas.)

Development in Gaseous Fuels and a New Singeing Application

LIQUEFIED petroleum gases are finding an application in various process-heating operations. In the textile industry butane is available as fuel for singeing, calendering, gas tenter-frame heating, and yarn-singeing operations. New cloth-singeing equipment has recently been developed and is discussed in the paper. (Paper No. TEX-53-2, by R. S. Van Note.)

Use of the Butted Seam by Textile Manufacturers

INCREASING use is being made of the butted seam by textile manufacturers, and this paper defines and illustrates the butted seam, describes many of its inherent properties, and outlines some of the advantages to be gained by its use in the finishing of woolens and worsteds, cottons, silks, and rayons (Paper No. TEX-53-3, by John M. Washburn.)

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 688 (Reopened), 704 (Reopened), 710–718, inclusive, as formulated at meetings of February 18 and 26, 1932, and Cases Nos. 709 (Reopened), 719, and 720 as formulated at meeting of March 25, 1932, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 688 (Reopened)

Inquiry: When used in the construction of the boiler pressure parts, can material made in accordance with Specifications S-2 be considered as being in compliance with Pars. P-2 and P-3?

Reply: Revised A.S.T.M. Specifications A89-31T provide for firebox-quality plate. The Boiler Code Committee recommends that pending the adoption of revisions to Specifications S-2 for Steel Plates of Flange Quality for Forge Welding to make them identical with A.S.T.M. Specifications A89-31T, the use of these revised specifications be permitted as being in compliance with Pars. P-2 and P-3. In line with the above recommendation the Committee has under consideration the following proposed revisions of Pars. P-2 and P-3:

P-2*a* Steel plates for any part of a boiler subject to pressure and exposed to the fire or products of combustion shall be of firebox quality in accordance with code specifications S-1 or S-2.

b Steel plates for any part of a boiler subject to pressure and not exposed to the fire or products of combustion shall be of firebox or flange quality in accordance with code specifications S-1 or S-2.

c Minimum tensile-strength limits other than those specified for flange and firebox plates may be used provided a range of 10,000 lb per sq in. is specified, that the maximum limit does not exceed 65,000 lb per sq in., and that the steel conforms in all other respects to Specifications S-1 and S-2.

d Seamless steel-drum forgings made in accordance with code Specifications S-4 may be used for any part of a boiler for which firebox quality only is specified or for which either firebox or flange quality is permitted.

P-3 Open-hearth steel pipe or steel tubing in accordance with Specifications S-18 or S-17 may be used for a boiler drum or other pressure part exposed to the fire or products of combustion, provided the nominal diameter of the pipe or tubing is not greater than 18 in.

CASE No. 704 (Reopened)

Inquiry: What is the maximum allowable unit joint working stress for Class 3 vessels, with double-welded lap-type longitudinal joints for thickness of $^3/_8$ in. or less under the provisions of Par. U-73 of the Code? It is noted that this allowable working stress is not provided for in Par. U-70.

Reply: It is the opinion of the Committee that the maximum unit joint working stress for double full-fillet lap welds for longitudinal joints of plates less than $^1/_4$ in. in thickness should be 5600 lb per sq in., and for plates $^1/_4$ in. and over in thickness, 7000 lb per sq in. of cross-section. It is proposed to restrict the use of full-fillet welded tanks to certain classes of service.

CASE No. 709 (Reopened)

Inquiry: Will it be permissible under the requirements of the Power Boiler Section of the Code to use electric-resistance-welded steel pipe or tubing which meets the requirements as to chemical and physical properties of Specifications S-18 and S-17 in the construction of Code boilers?

Reply: The Boiler Code Committee recommends that pending the adoption of specifications covering electric-resistance-welded steel pipe or tubing, such material be accepted on the basis of lap-welded pipe under Specifications S-18 and lap-welded tubes under Specifications S-17, provided all the requirements for lap-welded pipe or tubes in these specifications are met, and provided that electric-resistance-welded tubes under Specifications S-17 shall be normalized at a temperature above the upper critical point of the material.

CASE No. 710

Inquiry: Is it the intent of the provisions in Pars. P-107 and U-75 of the Code that the thickness of the reinforcing pad shall not be less than $^3/_4$ in., irrespective of the thickness of the shell or head to which it is fitted?

Reply: It is the opinion of the Committee that the $^3/_4$-in. thickness of reinforcing pads given in Pars. P-107 and U-75 was intended to apply only to the thicker shells or heads, and that a thickness of 1 in. may be taken as the least thickness of shell or head to which the requirement for $^3/_4$-in. reinforcing pads applies. A revision of these paragraphs is contemplated.

CASE No. 711

Inquiry: Can Par. P-203*d* be applied to determine the maximum pitch between the centers of through rods, or does this section apply only to the distance between the inner surface of the shell and the centers of through rods?

Reply: Par. P-203*d* is intended to apply to the spacing in stayed surfaces between the inner surface of a shell to which the surface is attached at its boundary and the centers of the adjoining braces. It is the opinion of the Committee that the spacings between the centers of through rods or other types of braces supporting a stayed surface should not exceed the limits specified in Par. P-199 or Table P-7.

CASE No. 712

(In the hands of the Committee)

CASE No. 713

Inquiry: Is it the intent of Par. P-303 of the Code to require two stop valves in the connection from a boiler to a common steam main when any one of the battery of boilers does not have a manhole opening?

Reply: It is the opinion of the Committee that if any one of two or more boilers connected to a common steam main is

not fitted with a manhole opening so that entry to the interior is impossible, that boiler need not be fitted with more than one stop valve. A revision of Par. P-303 to this effect is under consideration.

CASE No. 714

Inquiry: When outlets are formed by welding to the shell or head of a vessel a forged steel nozzle having a saddle flange and neck of seamless construction, is it not permissible to compute the reinforcing effect of the saddle flange and a portion of the neck, in place of the rules given in Par. U-75 of the code for the design of such reinforcing rings and reinforced nozzles?

Reply: It is the opinion of the Committee that the construction outlined in the inquiry may be considered as meeting the intent of the Code requirements provided:

1 The net cross-sectional area of the manufactured nozzle (having a saddle flange and neck of seamless construction) on a line parallel to the axis of the shell, shall not be less than the cross-sectional area of shell plate removed on the same line. This area shall be computed by multiplying the required shell-plate thickness (calculated by the formula in Par. P-180 and/or Par. U-20, using $E = 1$) by the maximum length of the shell plate removed by the opening.

2 The reinforcing value of such a nozzle shall consist of the cross-sectional area of the saddle flange plus the cross-sectional area of the neck to a height 3 times the thickness of the saddle flange.

3 All welds shall be strength welds as provided for by detail 6 of Fig. U-16.

4 In cases where the replacement value of the nozzle does not equal the above requirements, an inside reinforcing ring[1] may be used to provide the additional necessary replacement.

(Revisions of Pars. U-75 and P-107 of the Code are now in the hands of the Boiler Code Committee. This Case is issued to be used until the final revisions are adopted.)

CASE No. 715

(In the hands of the Committee)

CASE No. 716

Inquiry: Can any pressure part of a boiler of circular cross-section be fusion welded in accordance with the requirements of Pars. P-101 to P-111 of the Code? The part in question is a superheater header 14 in. in diameter having a shell thickness of 1 in.

Reply: In the opinion of the Committee such a structure is properly classified as a drum or shell.

CASE No. 717

(In the hands of the Committee)

CASE No. 718

Inquiry: Is it necessary to post-heat the longitudinal joints of cylindrical shells of heating boilers in the same manner as pre-heating is required for gas welding in Par. H-80 of the Code, or is such post-heating with electric welding optional? It is the impression of certain manufacturers that post-heating is not mandatory when electric welding is used.

Reply: In view of the advance in the art of welding since Par. H-80 was formulated, the Committee considers the provisions for preheating or post-heating to be unnecessary.

CASE No. 719

Inquiry: Is it necessary, under the requirements of Par. U-53 of the Code, to provide plugged threaded openings for inspection purposes in vessels approximately 10 in. in diameter by 24 in. long, built for 200 lb working pressure, such vessels being built for the distinct purpose of containing a mixture of lubricating oil and graphite, with a mechanical stirring device, the mixture to be forced out of the tank by means of compressed air? It is pointed out that such vessels are not subject to internal corrosion because of the nature of the contents, also that Par. U-62 would permit the omission of inspection openings.

Reply: It is the opinion of the Committee that where the actual service conditions of a vessel are such that the vessel is not subject to internal corrosion, the inspection openings required by Par. U-53 may be omitted. Where compressed-air tanks are used in combination with a substance which prevents corrosion on the interior, it is the intent of the Code that the inspection openings required by Par. U-53 may be omitted.

CASE No. 720

Inquiry: As the corner radius of a flanged and dished head may, according to Pars. P-197 and U-38 of the Code, thin down an amount not exceeding 10 per cent of the original metal thickness, cannot this allowable decrease in thickness also be applicable over the crown of the dish, and if so, is the factor of safety used in Pars. P-195 and U-36 sufficient to provide for this thinning condition?

Reply: It is the opinion of the Committee that the thickness of all portions of heads of semi-elliptical shape and the spherical portion of heads dished to a radius shall not be thinner than that required by the rules.

[1] The outside diameter of the reinforcing ring must at least equal the outside diameter of the saddle of the nozzle.

John Fitch

(*Continued from page 404*)

made manifest by the results of their toils, disappointments, and losses, is now held out as the original inventor of steamboats. Against such rank injustice, the facts set forth in these pages will continually protest."

Fitch's biographer says that he was in the boat that steamed around the Collect Pond in New York City with Robert R. Livingston and others in 1796. It is more than likely that the boat was Samuel Morey's. During a visit with his friend, Oliver Evans, another genius in transportation, who lived a generation before his time, Fitch told him he was heading for Kentucky "to establish steamboats in western waters."

A VISION OF THE STEAM RAILWAY

Arriving in Kentucky, he presently had not only completed a model of the boat with which he planned that establishment, but a model of a railway car complete in every detail—flanged wheels, miniature rails, everything with which to supplement it. So the vision of the first steam railway in America was also John Fitch's.

Early in 1798, the New York legislature transferred to Robert R. Livingston, at his instance, the exclusive grant to "the waters of New York" given to John Fitch in 1787, and which still had three years to run. The news presently penetrated Kentucky. On June 25, 1798, John Fitch made his will; a few days afterward he was dead, entering—on Westcott's testimony—the portals of his golden dreams a suicide.

A.S.M.E. Power Test Codes

Head-Measuring Apparatus[1]

WHEN the present revision of the A.S.M.E. Power Test Codes was begun in December, 1918, it was decided to shorten the text of the twenty-four test codes of prime movers and auxiliary apparatus by placing in a separate group of publications the supplementary data and information which is of general interest to the users of more than one test code. This group of publications was given the name of "Instruments and Apparatus," since the material which they contain deals primarily with the description of approved instruments and apparatus, together with methods of measurement.

The Committee in charge of this part of the Power Test Codes activity consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, E. B. Ricketts, and W. A. Sloan.

Part 4, dealing with Head-Measuring Apparatus, has just been completed, and is about to be presented to the A.S.M.E. Committee on Power Test Codes and the Council for approval. Before taking this step, however, the Committee on Power Test Codes is calling it to the attention of the public in general. Copies of this material are available to those interested, and may be obtained on application to the headquarters of the Society. The Committee and the Society will welcome suggestions for corrections and additions to this draft report. These comments should be addressed to Chairman Hirshfeld, care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

The several section headings of Part 4 are as follows: General, Float Gage, Flat Plate and Rod Gage, Water Column, Hook Gage, Stilling Box, Dial Pressure Gage, and Manometers.

To date ten of the twenty-one parts of "Instruments and Apparatus" have been completed, approved, and published. They are: General Considerations, Pressure and Temperature Measurements, Heat of Combustion, Determination of Quality of Steam, Speed Measurements, Time Measurements, Density Determinations, Determination of Viscosity of Liquids, and Leakage Measurements.

In the near future the Committee expects to release for review and final approval six additional parts of "Instruments and Apparatus:" namely, Electrical Measurements, Quantity of Material, Smoke-Density Determinations, Humidity Determinations, Linear Measurements, and Surface Area Measurements.

This Part 4 of "Instruments and Apparatus" is in effect a supplement to the new test code on Hydraulic Power Plants and Their Equipment which is now being formulated by a strong committee under the chairmanship of Ely C. Hutchinson. The other members of this reorganized committee are: Messrs. Charles M. Allen, Harold L. Doolittle, William F. Durand, Norman R. Gibson, Thomas H. Hogg, D. J. McCormack, Lewis F. Moody, R. V. Terry, William M. White, and James P. Growdon.

In December, 1931, this Committee held its first meeting in New York and made considerable progress toward the drafting of the new test code.

[1] Part 4 of "Instruments and Apparatus," Supplement to A.S.M.E. Power Test Codes.

Correspondence

CONTRIBUTIONS to the Correspondence Department of "Mechanical Engineering" are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Plasticity and Elasticity

TO THE EDITOR:

Dr. Nádai's book "Plasticity" (Engineering Series Monographs, McGraw-Hill Book Company, Inc., 1931) deals with two phenomena of vital concern to engineers, one, plasticity, with which, as the title indicates, the book is primarily concerned, and the other, elasticity, to which considerable space is given.

The writer begs that you will be good enough to give him space to advance certain views on these twin subjects in the hope of initiating a discussion which may shed light on a subject of fundamental importance. He is emboldened to advance these views because he has found that by applying the basis stated mathematically in Chapter 23 of Dr. Nádai's book, a reasonable explanation of the apparent mystery of the transverse strength of cast iron can be advanced.

This very old basis is that plane surfaces remain plane when a beam is loaded transversely, and as a corollary the transverse stress distribution is made up of parts of the stress-strain curves of the material in tension and compression, respectively. The possibilities of the application of this basis are alluded to in an article, "Elasticity and Plasticity," which appeared in the October, 1931, number of *Civil Engineering* (London). But the successful application is only possible when a very clear distinction is drawn between elasticity and plasticity, and the writer would ask whether Dr. Nádai has stressed the distinction sufficiently or whether he has not in fact used plasticity to some extent as a cloak to conceal quite unintentionally the real truth about elasticity.

In E. C. Bingham's book "Fluidity and Plasticity" (McGraw-Hill Book Company, Inc., 1922), Clerk Maxwell is quoted as follows:

> If the form of the body is found to be permanently altered when the stress exceeds a certain value, the body is said to be soft or plastic, and the state of the body when the alteration is just going to take place is called the limit of perfect elasticity.

Is this the truth about elasticity? The qualifying adjective suggests a doubt. Does not plasticity accompany elasticity even at very low stresses in the case of, for example, concrete or steel? Would it not be more practicable to say that the limit of elasticity of a material is reached when breakdown takes place? In the case of wrought iron or mild steel this would be at the "drop of the beam," and in the case of brittle materials like cast iron or cement, at fracture. It is agreed that (as Dr. Nádai shows) no clear differentiation between the elastic *cum* plastic state on the one side and the viscous state on the other side would be possible in the case of some materials.

This difficulty does not, however, justify the narrow limits on the use of materials of construction imposed by the con-

ventional mathematical theory of elasticity based on Hooke's law. The point that the writer would stress is that when some load below failure load is applied to a test piece, the resulting deformation is usually made up partly of elastic and partly of plastic deformation. When the load is removed, only the elastic deformation disappears immediately. Thus the stress imposed by the load immediately before removal is that corresponding with the elastic strain.

Applying this to the case of transverse stress distribution, it may be argued that unless the plastic be separated from the elastic component in the stress-strain graphs obtained by direct pull and compression, respectively, such stress-strain curves will not represent the transverse stress distribution. It is not suggested that Dr. Nádai's mathematical analysis is not of course perfectly general and correct, but the only example he gives in the chapter referred to raises a doubt. He gives as the example a material with the same stress-strain curves in tension and compression. The doubt is whether any such material other than one having straight-line stress-strain graphs exists.

The suggestion which the writer would offer is that where the tensile curve of a material shows, for example, concavity with respect to the strain axis, the compressive stress-strain curve may show convexity. This fact is often concealed in the case of cast iron, but is clearly marked in such test results as the writer has been able to find where the plastic component has been separated from the elastic component. It is shown very clearly in C. von Bach's treatise "Elastizität und Festigkeit," on page 36 (Julius Springer, Berlin, 9th ed., 1924).

The only example of a material having straight-line stress-strain graphs is apparently wrought iron. This suggests the query whether it is wise to base theories of elasticity on an ideal material. Some materials approximate to this condition, as Dr. Nádai states, below a certain limiting value. But the information of paramount importance which the engineer desires is that which will enable him to link up stress distribution at fracture or breakdown (i.e., above the limiting value) with the safe working conditions which are imposed well below that limiting value.

Edgar Marburg has shown in the case of that most important material, mild steel ("Tests of Standard I-Beams, Etc.," Proc A.S.T.M., Vol. 9, 1909, p. 378), that beams do not deflect above the limiting condition according to the same law which they appear to obey below the limiting condition. (It should be noted that only a very small curvature of the transverse-stress-distribution line produces a comparatively large alteration in transverse strength near the failure point.) It is by no means certain that the observed discrepancy can be attributed entirely to plasticity; it is quite probable that such materials obey an elastic law more comprehensive than Hooke's law which remains to be discovered.

A. C. VIVIAN.

Potters Bar, Middlesex, England.

TO THE EDITOR:

The writer appreciates very much the content of Mr. Vivian's letter, which has been kindly brought to his attention. He is fully in agreement with the opinion expressed by Mr. Vivian that some points mentioned by the latter deserve a more complete treatment than the one which they might have perhaps received in the past by those dealing with elastic and permanent strains, including the writer himself as far as he has been quoted. However, before proceeding to add a few details to the points which Mr. Vivian clearly refers to in his letter and which are the subject of his article in *Civil Engineering* (London), the writer will make a few remarks which, in connection with the general matter brought up by Mr. Vivian, seem to him in order.

Since the mathematical theory of elasticity was established, and, more recently, through the joint efforts of engineers and mathematicians, much valuable work has been added thereto, embracing phenomena formerly not treated, such as the small plastic or permanent deformations of solids or cases similar to those mentioned by Mr. Vivian. When studying the trend of these later developments, it will be conceded that much of the recently attained progress has probably been due rather to a concentration upon special cases, or perhaps, more exactly expressed, to the use or the invention of a few new *special* mechanical models of ideal solids, than to a generalization of mechanical laws. From this it immediately follows that each of these mechanical models of ideal solids—and there are already a number of them available, of which the perfectly elastic isotropic material is one—which first were more or less independently suggested and developed and only later were used in cases of practical interest, has its more or less narrow limits in practical application. The mathematical theory of elasticity is the classical and first example of such a development and has its natural limits of application, and the other models of solids, advanced later, which furnish solutions in other not less important cases of solids, have their own limits, as have all theories in mechanics. In each group, cases may easily be found or examples constructed which they will not fit. It therefore seems to the writer—and this is perhaps a reason which he may advance to justify partly these lines from a second point of view—that certain difficulties can sometimes be avoided if this will be borne in mind. The engineer has today a number of more or less independently developed models of solids which may prove useful when he wants to describe quantitatively states of stress or strain, and the perfectly elastic isotropic material is only one among the others—perhaps the most important one, but not the only one to which he may apply. It seems to the writer that some of the results obtained recently will perhaps not lose their value, even if it should be found that they are not valid as soon as certain conditions are changed (change of material, order of magnitude of strain, temperature, etc.).

One will perhaps reply to this by asking what the designer will then do, who, when driven by his urgent needs, has frequently neither the time nor the possibility to decide or to investigate whether in the special case in which he is interested all the assumptions on which certain available results were based are valid or not, or which are still valid and which are not. The answer to this is, first, that to our best knowledge we can hope only to obtain analytically expressible results or quantitative relations in the theory of strength of materials, if considerations are confined to sharply defined mechanical properties or quantities and based on idealized or simplified assumptions about the nature of the stress-strain relations or similar premises, when an investigation is made; and secondly, that permissible numerical data may be put in the hands of the engineer as far as they are available, but that frequently of far more importance to him is a general knowledge about the validity of the circumstances under which the available data were obtained, either by tests or derived from analytical considerations. Working out the majority of more or less independently developed parallel cases under varying assumptions will finally furnish the more complete picture required.

Coming now to the points mentioned in detail in Mr. Vivian's valuable remarks, as far as the writer can see, these refer to materials which, briefly, might be said to have *much elastic hysteresis*. A typical stress-strain diagram for such a material

might be described by curves as indicated in Fig. 1. It is understood that when introducing or speaking of such a diagram, even in its most simple form and for a given type of homogenous stress such as pure tension, compression, or pure shear, the conditions will still embody strong idealizations. One fundamental assumption implicitly made is that the momentary value of a strain depends only on the momentary value of the stress under which it appears (and not also on time, duration of load, previous operations, speed, plastic flow or after-flow, breakdown of structure due to repetition of cycles, etc.). In Fig. 1, *OA* represents the first loading curve, *ABC* the curve for first unloading, and *CDA* that for the second loading. Usually the latter reaches about the point *A* again, if the other phenomena are excluded. Repeating the cycle shown in Fig. 1 will alter but little the shape of the corresponding curves, at least as long as there are not too many cycles, but the steepness of their inclination may vary considerably, or, as expressed in another way by Mr. Vivian, if the stress changes sign (from a tensile stress to a compressive one). If from the beginning of operations attention is also directed to the shape of the unloading curves (including stress reversing) and not only, as is so frequently done, to that of the first loading curve in the stress-strain diagram, it will immediately be seen, for example, that a term such as the so frequently used "elastic limit" will not mean much. Even terms such as the "elastic" or "permanent" part of the strain may be hard to define. To the same stress, for example, s'' in Fig. 1, might be coordinated three different strains, namely $\epsilon_1 = FE$, if observed on the first or original loading curve, $\epsilon_2 = FB$, if taken during the first unloading, and finally $\epsilon_3 = FD$, if during the next loading. What can then be said, perhaps, is that after removal of a load in a tensile test (or of the corresponding stresses) there remains a strain $\epsilon_0 = OC$, which may be called the permanent part of the strain corresponding to s'. The shape of the hysteresis loops may be different for various materials, especially if we include certain plastic materials (soft metals) which start to yield under low stresses when the stress is reversed and the cycle is extended to include both tensile and compressive stresses or shearing stresses changing their direction. For these reasons and others, in the writer's opinion, there is not much gained in such cases as the ones referred to above in trying to give the term "limit of elasticity" some new or different meaning or justification—he prefers not to use or introduce this term at all in these cases where it is difficult or impossible to detect any special point whatever in which something essentially new or different occurs in the structure of the material as compared with any other point in the stress-strain curve. As far as the writer can see, Mr. Vivian in his discussion of the bending of cast-iron beams (mostly with rectangular cross-section) refers only to the *first* branch of the stress-strain curve *OA*, Fig. 1 (obtained by loading in tension or in compression). In other words, his distribution of transverse stress in bending refers to the instant at which the bar carries the load. To find, however, the exact amount the maximum deflection of such a bar would decrease if the load were removed, or, expressed in other words, to determine what might be called the "elastic part" of the total deflection under a load, would require the use of different stress-strain curves for the unloading of the bar from those used during the loading operation—in quite a similar way as has been shown by the writer in the case of the torsion of round bars of materials having elastic hysteresis. It will then be found that, contrary to the case of a perfectly elastic material (for which Hooke's law is valid), a bar of a material having considerable elastic hysteresis cannot (after removal of an external load, under which it was subjected to bending) remain without internal or residual stress. From this it furthermore follows that while there might be distinguished an elastic part of the total deflection, which could be determined when "unloading the beam," this is not true for the strains themselves in each element of the bar. After preloading, the elements will carry various amounts of stress, and hence it will not be justifiable to call their residual strains the "elastic" parts of their original total amounts.

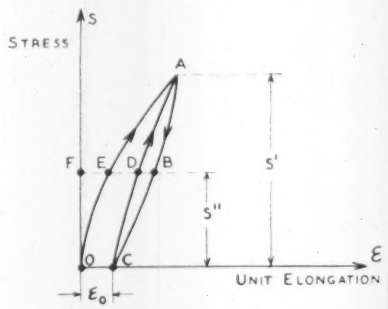

FIG. 1 STRESS-STRAIN DIAGRAM

The writer agrees with Mr. Vivian, that the most important material showing the same shape of curve on the tension as on the compression side when passing from the elastic into the plastic range is mild steel, but holds that the main content of the corresponding analysis (if the stress-strain curve is not restricted to having the above property) is more general and, if properly interpreted, can very well be used in the more exact analysis of stress and strain in bending or in torsion for such materials as cast iron or concrete, as has indeed been the case, recalling the early investigations of C. von Bach on the bending of cast-iron beams, of Eugen Meyer, of Mr. Vivian, and of still other investigators.

A. NADAI.[1]

East Pittsburgh, Pa.

The Quiescent Combustion Chamber

TO THE EDITOR:

Mr. Spanogle's paper[2] on the quiescent combustion chamber is a valuable contribution to the data on airless injection and combustion in oil engines.

Although the investigation throws light on many problems of interest to the designer, the investigation of the performance of the double-stem valve represents an attempt to solve the problem of "gradual injection."

In the writer's opinion, the solution of this problem will make it possible to choose the desired cycle, and consequently make the airless-injection oil engine superior in all respects to other engines.

Based on his own experience the writer does not believe that the double valve or the so-called double-stem valve will give satisfactory results, because while it increases the fuel discharge which is necessary because of the pressure drop in the fuel line, it has no influence on the pressure fluctuations in this line.

Fig. 10 of Mr. Spanogle's paper is an injection-rate curve showing two pressure drops, which probably represent the first two harmonics of the wave in the fuel line, assuming that the harmonics of the springs are too small to be shown.

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[1] Research Laboratories, Westinghouse Elec. & Mfg. Co. Mem. A.S.M.E.

[2] "The Quiescent Combustion Chamber," by John A. Spanogle. Trans. A.S.M.E. (1931), Paper No. OGP-53-10. Presented at the National Oil and Gas Power Meeting of the A.S.M.E., Madison, Wis., June 23–26, 1931.

Combustion follows the first pressure drop in a reasonable time, but does not show the influence of the second harmonic. This compares well with the writer's experience that only the first intense wave causes trouble and that subsequent waves are quickly damped and do little harm.

Further experiments with the auxiliary valve opening 0.0001, 0.0002, 0.0003, etc., up to about 0.0006 sec after the main valve, corresponding to the first harmonic, when tubes of the dimensions given are used, will, the writer is certain, yield interesting results.

The author is to be congratulated on the use of the term "compression-ignition fuel-injection engine," which is to be preferred to "solid-injection Diesel," since the results up to date indicate that the engine operates on a modified Otto cycle. If we have no hope of some day finding a way to control the combustion by gradual injection, the writer would propose, as the best way of avoiding confusion, discarding the term "Diesel cycle" and designating all solid-injection engines as "Otto-cycle engines."

O. L. RIEGELS.[3]

New York, N. Y.

TO THE EDITOR:

Apparently Mr. Riegels still believes that the investigation of double injection should be continued, but subsequent work with higher compression ratios, different valve timing, and improved fuels has confirmed my opinion that much improvement could be accomplished with single injection and without the complexities of double injection. I believe that Mr. Riegels is unduly apprehensive of the bad effects of initial pressure waves, and possibly lets them take the blame for other effects whose causes are not readily apparent.

His remarks on the cycles of operation are quite pertinent and are a further evidence that internal-combustion-engine designers are realizing that in high-speed operation there is no sharp definition of constant-volume or constant-pressure combustion cycles. Therefore it is misleading to associate "Otto cycle" with spark ignition or "Diesel cycle" with compression ignition at high speeds. Constant-volume combustion at high speeds is more nearly possible with compression ignition than with spark ignition (without detonation).

JOHN A. SPANOGLE.[4]

Hampton, Va.

Amendments to New York State's Engineers' License Law

IMPORTANT amendments to the Education Law of the State of New York in relation to the practice of professional engineering approved by Governor Roosevelt on March 29, 1932, are of interest not only to engineers residing in that state but to others as well. Some of the more important features of the law are given below.

Section 1449 defines a professional engineer as follows:

A person practices professional engineering, within the meaning and intent of this article, who holds himself out as able to perform, or who does perform, any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects, wherein the safeguarding of life, health, or property is concerned or involved, when such professional service requires the application of engineering principles and data.

Provisions restricting the use of the designation "professional engineer" are found in Section 1450, which makes it

. . . unlawful for any person to practice or to offer to practice professional engineering or land surveying in this state or use the title professional engineer or land surveyor or any title, sign, card, or device to indicate that such person is practicing professional engineering or land surveying or is a professional engineer or land surveyor, unless such person has been duly licensed under the provisions of this article.

Qualifications are detailed in Section 1452 as follows:

For license as a professional engineer evidence must be submitted that the applicant (1) is more than twenty-five years of age; (2) is a citizen of the United States or has legally declared his intention of becoming a citizen; (3) is of good moral character; (4) has satisfactorily completed an approved four-year high-school course or the equivalent thereof as determined by the department; (5) has had eight years or more of practical experience in professional engineering work of a grade and character satisfactory to the board; (6) has passed the prescribed examinations.

The following additional requirement regarding examinations has been added to this same section:

Notwithstanding anything herein contained, every applicant for license as professional engineer, otherwise required to take an examination, shall be required, in addition to all other requirements, to establish by written examination his competency to plan, structurally design, and supervise the construction of buildings and similar structures.

An important exemption based on certificates of qualification by the national council of state boards of engineering examiners has also been added as follows:

Upon the recommendation of the board the department may exempt from examination an applicant for license as professional engineer who holds a license or certificate to practice professional engineering issued to him upon examination by a legally constituted board of examiners in any other state or political subdivision of the United States, or who holds a certificate of qualification issued by the national council of state boards of engineering examiners, provided the requirement for such license or certificate was the full equivalent of the requirement in this state at the time it was issued, and provided, further, that the applicant's record fully met the requirement of this state in all respects other than examination.

Requirements for persons applying subsequent to January 1, 1937, are as follows:

Every person applying subsequent to January first, nineteen hundred thirty-seven, for a license as professional engineer, shall be required to pass the examination, and before admission thereto shall submit evidence that he has graduated from a college or school of engineering registered by the department as maintaining satisfactory standards. He shall also submit before admission to the examination evidence of practical experience in a professional engineering work of a grade and character satisfactory to the board.

In section 1453, provision is made for the issuing of licenses, for registration in the office of the county clerk of the county in which the licensed engineer maintains his principal place of business, and for annual reregistration.

Section 1454 provides for revocation and reissue of licenses, and Section 1455, penalties for violation of the law, public officials and courts being directed to aid in its enforcement.

[3] Designer, Consolidated Shipbuilding Corp., Morris Heights. Mem. A.S.M.E.

[4] Assistant Mechanical Engineer, National Advisory Committee for Aeronautics, Langley Field.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Power Requirements in Rolling Steel

TABLES OF ROLLING PRESSURES AND POWER REQUIREMENTS FOR ROLLING STEEL SHAPES. By F. Waldorf. American Iron and Steel Electrical Engineers, Pittsburgh, Pa. Paper, 12 × 18 in., 13 pp. of tables, $2.

THESE tables are based on a report published in 1913 by Dr.-Ing. J. Puppe, of Düsseldorf, based on work done under the auspices of the German Steel Manufacturers' Association. The tables presented in the American publication are taken from Puppe's report, but recomputed where necessary into English units. This is an important document which will be helpful to American and English designers of steel rolling machinery, and has been published in the United States by the *Iron and Steel Engineer*, the official organ of the American Iron and Steel Electrical Engineers.—L. C.

Hydraulics for Engineers

HYDRAULICS FOR ENGINEERS. By Robert W. Angus. Isaac Pitman & Sons, London and New York, 1931. Cloth, 6 × 9 in., 304 pp., illus., diagrams, charts, tables, $3.50.

REVIEWED BY CLYDE W. HUBBARD[1]

PROFESSOR ANGUS' book deals entirely with the action of water in motion. It is stated in the preface that the customary section on hydrostatics has been omitted to shorten the book. This permits a much more extensive discussion of the action of moving water, although there is an advantage for beginners in having at least a brief discussion involving total pressure and center of pressure on simple plane areas.

The book is divided into three parts: Part I treats of the flow of water in pipes, orifices, weirs, and open channels. Part II deals with the subject of hydraulic turbines and centrifugal pumps. Part III takes up the subject of non-uniform flow, an important part of practical hydraulics often only briefly discussed by most elementary books.

A discussion of the flow in curved channels and vortex motion is found in Appendix I. Appendix II describes the computations made to obtain the shape of the surface in a rotating cylinder.

At the end of each chapter there are many problems which illustrate the subject-matter. There are answers to these problems given in the back of the book, making the work especially valuable to those who wish to use it for self-study. The fact that there are answers to the problems does not detract from the value of the book as a classroom text.

[1] Instructor in Hydraulics, Worcester Polytechnic Institute, Worcester, Mass.

The text as a whole is very clearly written and up to date. It differs from the ordinary run of short books on hydraulics by its omission of a discussion of hydrostatics, an absence of involved mathematical treatment of problems, and the inclusion of such modern subjects in hydraulics as the Rehbock weir formula, a description of the principles of the Gibson and Allen salt velocity methods of water measurement, the Kaplan turbine, descriptions of recent hydroelectric plants, and the discussion of surge tanks, with examples of their solution by arithmetical integration. The illustration of arithmetical integration is of value as this convenient method of computation may be applied to other complicated problems than those involving the design of surge tanks.

Behemoth: The Story of Power

BEHEMOTH: THE STORY OF POWER. By Eric Hodgins and F. Alexander Magoun. Doubleday, Doran & Co., Inc., Garden City, N. Y., 1932. Cloth, 6 × 9 in., 354 pp., illus., $3.50.

THE authors of this entertaining and instructive history of the birth and development of power claim to have little idea of what is wrong with machine civilization, and say that their book "defends no one and indicts no one. Its purpose is purely narrative."

And narrative it is, to be sure, in a refreshing way, as the following quotation from a chapter opening that tells of the setting out to sea of the *Savannah*—first steamship to cross the Atlantic—will prove. "When Captain Moses Rogers gave his orders to cast off in the harbor of Savannah, Georgia, on a late day in May, 1819, it became evident to his townspeople that his insanity was not of the temporary sort they had hoped..... A steam engine in mid-ocean? It was unthinkable." And again, in introducing a chapter entitled "The Iron Colt," one reads: "For some time prior to the year 1763 the fellow artillery officers of Nicholas Joseph Cugnot had held the suspicion that something was wrong with him. Something was. He had an idea. He was being teased and tormented by a notion, which he scarcely dared to utter, that the steam engine might be applied to a moving vehicle."

These two examples illustrate not only the enticing style that leads the reader along from page to page and from invention to invention, but also the invariable conflicts of originators and inventors with the conservatism of their times so frequently emphasized by the unreeling of the story of power.

Technical men will find in this book a brief and easily readable history of the development of steam and water power, electricity, the railroad, the steamship, and the automobile.

Hero's aeolipile, De Caus's fountain, Branca's drug stamp, the Marquis of Worcester's "water-commanding" engine, Papin's digester, Savery's "miner's friend," Newcomen's "atmospheric" engine, Humphrey Potter's valve gear, and finally James Watt's separate condenser, bring the story of steam down to the beginning of the industrial revolution, from which further development proceeds to Corliss, Parsons, and the present day.. And similarly from Thales of Miletus the history of electricity is brought down to date with broad sweeps of significant discoveries linked with the most entertaining of "human interest" side lights on the discoverers involved and their foibles. It is all very exciting and realistic, and lopes along much too easily for history.

One can find especial pleasures in certain technical descriptions, as, for example, that of the Stephenson link. The paragraph gets off to a good start as follows:

"But by 1841 there had finally been developed a device known (with no particular justice, but with a unanimity which still earmarks it today) as the Stephenson Link."

Then comes the description:

"By means of this, fixed eccentrics fastened to the driving axles, drove a curved rocker arm in a leisurely back-and-forth movement. The rocker arm was slotted, and in this slot there could move from top to bottom (as controlled by a lever available to the engineer) a block of metal by which the rod connected to the valve was driven. When the metal block was at the extreme top of the rocker-arm slot the valve would open to its fullest width and stay open its longest time. As the metal block was moved, by the action of the engine driver, closer and closer to the center of the rocker arm, the motion of the valve became less and less, thereby producing a shorter and shorter cut-off until, in the exact center of the rocker arm, the valve moved not at all and the engine was out of gear. Below the center of the arm the valve put the engine in reverse—for a reason analogous to that whereby the seasons are reversed for any one who travels from the northern to the southern hemisphere."

Would that many engineers could suit words so profitably to their uses!

In their story of Faraday the authors quote one of his sayings that may be put into the mouths of their critics: "Lectures that really teach will never be popular; lectures which are popular will never really teach." But in this age of diminished effort the sugar coating of lively interest that Messrs. Hodgins and Magoun have placed about their pill of history will attract many to it to their advantage and instruction, and the somewhat cryptic concluding paragraph may, perhaps, serve as a defense for such spirits as those of Watt and Faraday. "The men who brought power into the world are not properly described by the term 'crass materialists' so often applied to them. Of the two great media of power, steam and electricity, one is imponderable and both invisible. These are no materials; and there was little materialism in the minds that worked with them. What they sought to solve and to create and what their successors today would equally solve and create, is something entirely different—mystery, and a religion."—G. A. S.

Books Received in the Library

HANDBUCH DER LANDMASCHINENTECHNIK. Vol. 2, part 1, Die Geräte und Maschinen zur Ernte, die Maschinen zur Körnergewinnung und Saatgutaufbereitung. By G. Kühne. J. Springer, Berlin, 1932. Paper, 8 × 11 in., 264 pp., diagrams, charts, tables, 56 r.m. This section of the handbook is devoted to harvesting, threshing, and cleaning machinery. These subjects are treated comprehensively, with a wealth of drawings showing the details of various machines and with detailed explanations of their methods of working. The work provides an exhaustive encyclopedia of farm machinery.

MECHANICAL HANDLING AND STORING OF MATERIAL. 2 vols. By G. F. Zimmer. Fourth edition. Crosby Lockwood & Son, London, 1932. Cloth; vol. 1, 426 pp.; vol. 2, 896 pp.; 7 × 11 in., illus., diagrams, 63 s. This edition consists of a reprint of that of 1922, with seven added chapters in which modern developments are described and the text generally brought up to date; the added matter being about one hundred pages. The book is the most comprehensive description of conveying and transporting apparatus in print. Machines for the continuous and intermittent handling of material and for loading and unloading are described and their use illustrated by accounts of many installations. Such subjects as coal and ash handling, grain storage, and automatic weighing are treated. A chapter is devoted to excavators. Many drawings and cuts are included.

MECHANISCHE KLÄRANLAGEN FÜR STADTE UND GEMEINDEN. By O. Mohr. R. Oldenbourg, Munich and Berlin, 1931. Paper, 5 × 7 in., 40 pp., illus., diagrams, tables, 2 r.m. This little pamphlet is concerned with mechanical sewage-purification plants for small communities. The principles underlying the planning of these plants and the precautions necessary in operating them are set forth in the briefest manner.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN. Vol. 1, No. 8, pp. 175-200, December, 1931. V.D.I.-Verlag, Berlin. Paper, 9 × 12 in., illus., diagrams, charts, tables, 3 r.m. Contains three papers by investigators connected with the research staffs of large German machine works. The first discusses the testing and valuation of foundry core sands and binders. The second is a mathematical investigation of buckling stresses in rectangular plates. The third describes a new method of firing heating furnaces with mixed coke and blast-furnace gases.

MODERN DIESEL, a Review of High-Speed Compression Ignition Engines. Iliffe & Sons, Ltd., London, 1932. Cloth, 5 × 8 in., 142 pp., illus., diagrams, charts, tables, 2 s. 6 d. An elementary handbook describing the origin of this engine, its principles and construction, and its advantages. The principal types for automobiles, aircraft, and marine service are described briefly.

LES MOTEURS DIESEL SANS COMPRESSEUR ET LES MOTEURS SEMI-DIESEL. By M. Seiliger, translated from the German by A. Schubert. Dunod, Paris, 1932. Cloth, 6 × 10 in., 469 pp., illus., diagrams, charts, tables, 142 francs. This translation of Seiliger's work on airless-injection and semi-Diesel engines has been extended by adding information upon recent French engines and summaries of his books upon the thermodynamics of internal-combustion engines and large Diesel engines, which have not appeared in the French language. The book discusses the theory and design of these engines, describes a larger number of European types, and gives their characteristics. This edition is much cheaper than the German original.

NAVAL ARCHITECT'S, SHIPBUILDER'S AND MARINE ENGINEER'S POCKET BOOK OF FORMULAE, RULES, AND TABLES. By C. Mackrow and L. Woollard. Thirteenth edition. Crosby Lockwood & Son, London, distributed by Simmons-Boardman Publishing Co., N. Y., 1932. Leather, 4 × 7 in., 732 pp., diagrams, charts, tables, $6. The new edition of this well-known collection of information has been thoroughly revised. The sections summarizing the rules of the Board of Trade and the registration societies, and the Admiralty tests for materials have been brought up to date. New recommendations on freeboard, subdivisions, life-saving appliances, etc., have been included. The book covers the data needed frequently by shipbuilders.

NEW CONCEPTIONS OF MATTER. By C. G. Darwin. Macmillan Co., New York, 1931. Cloth, 6 × 9 in., 224 pp., illus., diagrams, $3. This book, based on Professor Darwin's Lowell Institute lectures in 1931, is a clear description of the broad features of the new mechanics in non-technical language without the use of mathematics. By extensive use of analogies with familiar phenomena, he presents a clear picture of the ideas at present current about the basic constituents of the physical world, and explains the foundations for these conceptions. The book is not light reading, but calls for no technical knowledge upon the part of the reader.

POWER PLANT MANAGEMENT. By W. N. Polakov. McGraw-Hill Book Co., New York and London, 1932. Cloth, 5 × 8 in., 176 pp., charts, tables, $2. This work outlines a method for organizing the "human side of work in the power house" which has proved efficient and economical in various factories and power plants. The duties of the various employees are discussed, methods of accounting and recording are shown, and wage methods treated.

PRINTING TRADES BLUE BOOK, Seventeenth edition, 1932. Edited and published by A. F. Lewis & Co., New York. Cloth, 6 × 8 in., 842 pp., illus., $15. A directory of printers, bookbinders, dealers in paper and other supplies, lithographers, and others connected with the printing trades in the metropolitan district of New York and in New Jersey. Includes also a list of associations, clubs, and unions, and a directory of paper watermarks and brands.

PROBLEM OF FLUCTUATING LOADS ON BOILERS. By G. E. Hider. J. B. Lippincott Co., Philadelphia, 1931. Leather, 6 × 9 in., 115 pp., diagrams, charts, tables, $3. Under rapidly fluctuating loads, such as those imposed upon rolling-mill engines and hoisting engines, efficiency of steam production often becomes a less important factor in the economy of operation of the plant than security against interruption of supply or regularity of pressure or temperature. In this work the reactions caused by fluctuating boiler loads are analyzed, and the means available for dealing with these fluctuations are examined. The importance of water content is pointed out. The author claims this to be the first book to analyze important reactions that occur in boilers and are important factors in their efficiency.

REGELN FÜR ABNAHMEVERSUCHE AN DAMPFTURBINEN. DIN 1943, 6 pp., 1.50 r.m. REGELN FÜR ABNAHMEVERSUCHE AN RÜCKKÜHLANLAGEN. DIN 1947, second edition, 14 pp., 3 r.m. RICHTLINIEN ZUR BEMESSUNG VON WÄRME- UND KÄLTESCHUTZANLAGEN. (Regelangebote.) DIN VORNORM 1951. 42 pp., 4.50 r.m. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., diagrams, charts, tables. These three pamphlets contain standard methods for the conduct of acceptance tests for cooling apparatus and for steam turbines, and a standard form of bid for heat-insulating materials and installations. These standards have been prepared for the Verein Deutscher Ingenieure and adopted by it.

REVISED CALLENDAR STEAM TABLES (1931). Calculated by H. Moss from the new data and formulae of the late H. L. Callendar. Edw. Arnold & Co., London, 1931. Cloth, 8 × 11 in., 56 pp., tables, 10 s. 6 d. These tables are intended to supersede the Enlarged Callendar Tables published in 1924, and are based upon the modified equations resulting from Professor Callendar's recent investigations of steam at very high pressures. Two tables showing the properties of steam are included. The first shows the properties of low-pressure dry saturated steam and water at saturation temperature for pressures from 0.2 to 30 lb per sq in. (absolute); the second of dry saturated and superheated steam for pressures from 1 to 4000 lb per sq in. (absolute).

REVISED HEAT DROP TABLES (1931). Calculated by H. Moss from the new data and formulae of H. L. Callendar, published for the British Electrical and Allied Industries Research Association. Edw. Arnold & Co., London, 1931. Cloth, 8 × 11 in., 79 pp., tables, 12 s. 6 d. These tables have been calculated in conformity with the results obtained by Professor Callendar in his last measurements of the properties of steam at high pressures. They give the adiabatic heat drop of one pound of steam in British thermal units for initially dry saturated or superheated steam of pressures from 100 to 3200 pounds per square inch gage. A table for low-pressure dry saturated steam (14 to 19 pounds per square inch, absolute) is also included. The tables are believed correct within 0.1 Btu.

LE SERVICE D'ENTRETIEN DANS LES USINES. By L. Faure. Dunod, Paris, 1932. Paper, 7 × 10 in., 85 pp., diagrams, charts, tables, 24 francs. This book presents in detail a plan for the organization and management of repair shops in factories. Equipment, personnel, cost keeping, routing, etc., are discussed. The system is illustrated by application to a steel works.

SIGNALS FROM THE STARS. By G. E. Hale. Charles Scribner's Sons, New York and London, 1931. Cloth, 5 × 8 in., 138 pp., illus., diagrams, charts, $2. Dr. Hale here republishes, in somewhat different form, some recent contributions to *Scribner's Magazine*, *Harper's*, and to *Popular Astronomy*. The book tells, in non-technical language, the possibilities of large telescopes and describes the building of the 200-inch telescope now being constructed by the California Institute of Technology. Dr. Hale also discusses the exploration of the solar atmosphere and signals from the sun.

SYMPOSIUM ON MALLEABLE IRON CASTINGS held at joint meeting of the American Foundrymen's Association and the American Society for Testing Materials, Chicago, June 26, 1931. °American Society for Testing Materials, Philadelphia. Paper, 6 × 9 in., 122 pp., illus., diagrams, charts, tables, $0.75. This symposium aims to provide engineers with authoritative data in concise form on the properties of malleable iron and castings poured from it. It has been prepared by a committee of the two societies from information supplied by a large number of manufacturers and others. The manufacture of malleable-iron castings is described and the available data on the chemical, physical, mechanical, and electrical properties of malleable iron are given. Higher-strength and cupola malleable iron are discussed; the necessity for cooperation between designer and foundry is treated, and current specifications are summarized. Methods for determining the machinability of castings are investigated, and the corrosion of malleable iron is considered.

SYMPOSIUM ON WELDING. American Society for Testing Materials. Philadelphia, 1931. Cloth, 6 × 9 in., 151 pp., illus., diagrams, charts, tables, $1.75. Contains the eleven papers presented at a meeting of the Society in Pittsburgh, March, 1931, with the discussions that ensued. These include a general survey of processes, an account of processes for welding aluminum, and papers on materials for fusion welding, modern applications of arc welding and recent developments in gas welding. Several other papers discuss such matters of inspection and testing as the use of the stethoscope, gamma-ray testing, magnetic testing, and fatigue and impact tests.

TABELLEN UND DIAGRAMME FÜR WASSERDAMPF, berechnet aus der spezifischen Wärme. By Oscar Knoblauch, E. Raisch, H. Hausen, and U. Koch. R. Oldenbourg, Munich and Berlin, 1932. Paper, 8 × 11 in., 40 pp., charts, tables, 4.60 r.m. This is a revised and enlarged edition of Knoblauch, Raisch, and Hausen's well-known steam tables. In the interval since the first edition additional investigations have been made of the specific heat of steam at pressures between 30 and 120 atmospheres, which are used in the new tables. The tables have also been extended to 225 atmospheres by careful extrapolation, based on unpublished researches at 200 atmospheres. A chart for calculating the specific volume of superheated steam at any temperature and a Mollier diagram are included.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES DE CHIMIE, DE PHYSIQUE, DE BIOLOGIE ET DE TECHNOLOGIE, Vol. 8, 1927–1928, Part 1. Gauthier-Villars et Cie, Paris; McGraw-Hill Book Co., New York, 1931. Cloth, 9 × 11 in., 1101 pp., diagrams, charts, tables, $10. This annual presents, year by year, a compilation of the numerical constants and data that have appeared in the important scientific periodicals of the period under review, thus enabling those interested to obtain the latest figures without the labor of examining many scattered sources. The present part covers mechanics, heat, light, electricity, and magnetism. Titles and explanatory matter are given in English as well as in French. References are given to the sources of all data. The set is of great value to all scientific libraries and research institutions.

DIE TECHNISCHEN GRUNDLAGEN DER BRIKETTIERUNG VON NACH FREIBERGER SPÜLGASVERFAHREN ERHALTENEM BRAUNKOHLENKOKS. (KOHLE—KOKS—TEER, Bd. 28.) By H. Menzel. Wilhelm Knapp, Halle (Saale), 1931. Paper, 7 × 9 in., 61 pp., illus., diagrams, charts, tables, 6.60 r.m. Gives the results of an investigation to determine the proper conditions for briquetting the residual coke from the circulating-gas method of brown-coal distillation. The influence of various factors upon the quality of the briquets was studied carefully, and the commercial possibilities are considered.

THEORETICAL PHYSICS. Vol. 1. Mechanics and Heat. Newton-Carnot. By W. Wilson. E. P. Dutton & Co., New York, 1931. Cloth, 5 × 9 in., 332 pp., diagrams, charts, tables, $6. Professor Wilson's aim is to present an account of the theoretical side of physics which will be sufficiently comprehensive to be useful to students, without being too elaborate and voluminous. This volume, the first of three, deals with mechanics and heat. The subjects are developed according to their historical growth, and this volume is entirely classical, its dynamical part being based on Newton's foundations, but the ways in which recent advances have developed out of the classical theory are shown.

THÉORIE ET TECHNOLOGIE DES ENGRENAGES. Vol. 1. By J. Perignon, preface by R. Bricard. Dunod, Paris, 1932. Paper and bound, 7 × 10 in., 278 pp., diagrams, charts, tables, 72 francs; bound, 81 francs. This, the first of two volumes on gearing, discusses their mathematical theory from the viewpoint of the designer. After a brief review of the kinematic principles that apply to gearing, the author discusses the different classes of gears and describes the current types of each class. The geometric and kinematic principles of each type are presented, the conventions adopted in its design are explained, and its dynamic principles are studied. The result is a good text.

THEORY OF GROUPS AND QUANTUM MECHANICS. By H. Weyl, translated from the second revised German edition by H. P. Robertson,

E. P. Dutton & Co., New York, 1931. 422 pp., charts, tables, $6. This work aims to present the essentials of the theory of groups and of quantum mechanics in an elementary manner, and to show how the concepts arising in the theory of groups find their application in physics. The general principles of scalar wave mechanics and the necessary mathematical disciplines are first presented, after which the applications of the group of Euclidean rotations and the permutation group to the classification of atomic spectra and to molecular structure are discussed. There is an extensive bibliography.

TRAINS, TRACKS, AND TRAVEL. By T. W. Van Metre. Third edition. Simmons-Boardman Publishing Co., New York, 1931. Cloth, 7 × 10 in., 268 pp., illus., diagrams, tables, $3. A profusely illustrated history and description of railroads, their equipment and their operation, written in the simplest language. Written primarily for boys, the book is by no means unsuited to older readers who are curious about the construction, equipment, and working of our railroad system.

THERMISCHE UND DYNAMISCHE BEDINGUNGEN DER EISBILDUNG IN WASSERLÄUFERN. (Geofysiske Publikasjoner, vol. 9, no. 1. Norske Videnskaps-Akademi i Oslo.) By O. Devik. Grondahl & Sons, Oslo, 1931. Paper, 9 × 12 in., illus., diagrams, charts, tables, 9.50 kr. This work presents the results of an unusually thorough investigation of the formation of ice in rivers. The author has studied the effects of radiation and evaporation upon the rate of heat flow and other physical phenomena, and has analyzed the part played by the various elements of the cooling process. Conditions in standing and flowing water are discussed.

TOOL AND DIE DESIGN. By C. B. Cole and F. W. Curtis. American Technical Society, Chicago, 1932. Cloth, 6 × 9 in., 140 pp., illus., diagrams, tables, $1.50. A practical, elementary treatise discussing the essentials of tool and die design and illustrating common problems by examples. The book is suitable for trade school use or home study.

TREATISE ON PHOTOELASTICITY. By E. G. Coker and L. N. G. Filon. Cambridge University Press, London; Macmillan Co., New York, 1931. Cloth, 7 × 11 in., 720 pp., illus., diagrams, charts, tables, $17.50. This handsome volume, in which two leading authorities in this field present a comprehensive survey of it, will be indispensable to all students of the subject. The book opens with a presentation of the elements of the theory of physical optics and the theory of elasticity after which an account of the historical development of photoelasticity is given. The remainder of the book deals with various problems having scientific and practical engineering interest, such as the flexure of beams, holes and cracks, stresses in planes involving straight and circular boundaries, and the testing of materials. A chapter is devoted to methods for determining the effects of load and strain on structures and machines. The illustrations, in color, are of unusual excellence, and a good bibliography is included.

DIE TROCKENTECHNIK. By M. Hirsch. Second edition. J. Springer, Berlin, 1932. Cloth, 6 × 9 in., 484 pp., illus., diagrams, charts, tables, $8.64. This book aims to give a comprehensive presentation of the scientific principles of drying processes, with a systematic description of these processes and the machinery for carrying them out. The theory of drying and the scientific data available to the designer are first treated, after which the author discusses the various methods and machines in use and their application to different materials, meats, grains, paper, textiles, dyes, fuels, etc. Attention is paid both to theory and practice, resulting in a book of use to all.

VEGETABLE FATS AND OILS. American Chemical Society Monograph Series No. 58. By G. S. Jamieson. Chemical Catalog Co., New York, 1932. Cloth, 6 × 9 in., 444 pp., diagrams, tables, $6.50. This book is intended to include in one volume as much information as possible about these fats and oils. All the existing information about their chemistry, production and utilization has been collated and summarized in convenient form, and references to sources of additional details added. The volume will be unusually valuable as a work of reference.

WEISS-, HOHL- UND GERÄTEGLAS (Das GLAS, Bd. 7). By F. Späte. Akademische Verlagsgesellschaft, Leipzig, 1931. Paper and bound, 6 × 9 in., 192 pp., illus., diagrams, charts, tables, 14.80 r.m.; bound, 15.80 r.m. A useful treatise on the manufacture of hollow glassware. The preparation of mixtures, the construction and operation of glass furnaces, methods of blowing and shaping, and the varieties adapted to special purposes are discussed from a practical viewpoint. Bibliographic footnotes are numerous.

WINDEN UND KRANE, Aufbau, Berechnung, Konstruktion. Two parts. By R. Hänchen. J. Springer, Berlin, 1932. Paper, 8 × 11 in., 138 pp., diagrams, charts, tables; part 1, 6.60 r.m.; part 2, 7.20 r.m. These are two instalments of a textbook and reference book which will appear in six sections, each of which treats of one topic and can be purchased separately. These two sections discuss general subjects, such as methods of driving cranes, materials and their strength, and crane and hoist elements, hooks, chains, ropes, pulleys, drums gearing, brakes, etc. The treatment is concise and practical, adapted to the needs of the busy designer, and gives a good survey of modern practice in Germany. Line drawings of details are numerous.

ZEITSCHRIFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK. INHALTVERZEICHNIS DER BÄNDE 1–10, 1921–1930. V.D.I. Verlag, Berlin, Paper, 7 × 11 in., 52 pp., 8 r.m. This German journal of applied mathematics and mechanics contains much material of value to engineers upon such subjects as the mechanics of structures, the theory of elasticity, gears, hydraulics and hydromechanics, turbines, etc. The index to the first ten volumes now available provides references by authors and by subjects and will be a great convenience.

Modern Research Organizations and the American Patent System

(Continued from page 398)

system inaugurated, the obvious intention was to stimulate the individual inventor to create new, useful things. His reward was to be his right to exclude others from the use of his creations for a limited period if he so desired. So long as inventions were largely concerned principally with rather concrete things specifically related to limited fields, it made little difference to the public whether the inventor exploited his own inventions or transferred his rights to others who possessed similar rights. In the period preceding the industrial-research laboratory, patentable invention was essentially a haphazard affair.

With the advent of the fully equipped industrial-research laboratory patentable invention has become in large measure a matter of reasonably certain calculation. Further, as we have seen, many of the patents are likely to have a much wider control than those of the earlier period. These facts cannot help but raise questions as to whether modification in the property rights granted, in the rules for determining what is patentable, and in the handling of patents, may not be in order. One thing is clear, nevertheless, and that is that the incentive of the patent system is still potent in the production of new, useful things, the net results of which are of great value to the public.

In conclusion, I can only reiterate my belief that the few words which make up Clause 8 of Section VIII of the Constitution, and on which the entire patent system is founded, have been among the most potent provisions of that remarkable document in influencing the growth of our country. If this provision has been potent and necessary in the past, it will, I believe, be more potent and more necessary in the future, although the manner and method of its application to the growth and betterment of our national existence may be different. The industrial-research laboratory is not a passing phenomenon. It has become a part of the very vitals of our industrial life. In my judgment its creative works will, during the next few years, do more to modify the operation and administration of our patent system than any single factor which has yet entered into it.

CURRENT MECHANICAL ENGINEERING LITERATURE

Selected References From The Engineering Index Service

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AIRPLANE ENGINES

COOLING. High Temperature Liquid-Cooled Aircraft Engines. A. Nutt. Aero Digest v 20 n 3 Mar 1932 p 36–7, 90 and 94. Possibilities of liquid-cooled design on basis of experiences with Curtiss Conqueror engines, power curves showing effect of cooling medium temperature on power and best economy fuel consumption; specific consumption of as low as 0.39 lb per bhp-hr.

COWLING. Engine-Cooling Problems With Venturi Cowling. R. R. Higginbotham. Soc Automotive Engrs J v 30 n 2 Feb 1932 p 84–92. Application of theoretical formula for determining required entrance and exit areas; experimental data and recommendations for 9-cyl. radial engines in 300 to 450-hp range; layout of venturi cowl for 300 to 450-hp engine in airplane expected to travel 140 to 180 mph.

HEAT TREATMENT OF PARTS. Heat Treating Important Link in Airplane Engine Construction. H. R. Simonds. Iron Age v 129 n 11 Mar 17 1932 p 666–9. Review of improvements in handling of material through heat-treating department of Pratt & Whitney Aircraft Co., Hartford, Conn. Company has considered heat treating as integral part of production sequence and has raised operating standards accordingly.

VIBRATIONS. Praktische Drehschwingungs-Untersuchung von Luftfahrzeug-Triebwerken. K. Luerenbaum. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 4 Feb 29 1932 p 105–13. Methods for theoretical and experimental investigations of torsional vibrations of aircraft power plants with particular regard to use of various recording instruments; tabulation of vibration characteristics of in-line and radial engines.

AIRPLANES

DESIGN. Le cycle-voilier Borghèse-Parizzi. G. Borghèse Negrett and E. Parizzi. Air v 14 n 296 Mar 1 1932 2 p. Design and operating principles of airplane with rotating cylinder mounted along leading edge of wings; motive power supplied by pilot through pedal arrangement.

Weight Reduction Versus Drag Reduction in Design. K. D. Wood. Aviation Eng v 6 n 3 Mar 1932 p 18–20 and 39. Method for determinating how much weight may be added to airplane when drag is reduced any given amount, assuming constant engine horsepower, flying speed, and wing area; application to four specific airplanes; relationship between drag reduction and increase in cruising range for long range airplanes.

PERFORMANCE CALCULATION. Climb Relationships. W. R. Andrews. Flight v 24 n 1205 and 1209 Jan 29 1932 (supp) p 96a–96d and Feb 26 (supp) p 174d–174g. Determination of climbing speed at any weight, knowing speed for any other weight; rate of climb for any weight, from known conditions at another gross weight; absolute ceiling in terms of ground level rate of climb, from rate of climb and absolute ceiling for another weight; rate of climb and ceiling in terms of weight, engine output, air-screw efficiency and stalling speed, where test not available.

PROPELLERS. Controllable and Automatic Aircraft Propellers. D. A. Dickey and O. R. Cook. Soc Automotive Engrs J v 30 n 3 Mar 1932 p 105–10 (discussion) 110–1. Needs of different classes of airplane for different types of changeable-pitch propellers; design and operating principles of various controllable-pitch propellers; Hart-Eustis, Smith Engineering Co., Spencer Heath, and Hamilton Standard Propeller Corp. propellers.

SHOCK ABSORBERS. Dynamic Testing of Airplane Shock-Absorbing Struts. P. Langer and W. Thome. Nat Advisory Committee Aeronautics—Tech Memo n 656 Jan 1932 4 p 3 supp plates. Measurement of perpendicular impacts of landing gear with different shock-absorbing struts against drum-testing stand; tests with pneumatic shock absorbers having various degrees of damping, liquid shock absorbers, steel-spring shock absorbers and rigid struts.

WINGS. Characteristics of Clark Y Wing Model Equipped With Several Forms of Low-Drag Fixed Slots. F. E. Weick and C. J. Wenzinger. Nat Advisory Committee Aeronautics—Report n 407 1932 9 p. Investigation to develop low-drag fixed slot for airplane wing which would avoid complications and maintenance difficulties of present movable-type Handley Page slot; best combination of wing and fixed slot that was developed had max. lift coefficient of 1.751; angle of attack for max. lift raised to 24 deg; min drag increased 52.6 per cent.

ALLOY STEELS

MACHINABILITY. New Ferrous Alloys. P. Mabb. Mech World v 91 n 2354 and 2355 Feb 12 1932 p 151 and Feb 19 p 179. Relations between physical properties, composition, and machinability of typical alloy steels.

ALLOYS

ACID-RESISTING. Acid-Resisting Alloys. T. E. Green. World Power v 17 n 98 Feb 1932 p 108–9. Importance of sound chemical or metallurgical knowledge to engineer; concise summary of effects of various acids on materials used in construction.

[See also *Aluminum Alloys; Bearing Metals; Beryllium Alloys; Chromium-Iron Alloys; Chromium-Nickel Alloys; Copper Alloys; Duralumin; Magnesium Alloys.*]

ALUMINUM

MACHINING. Machine Tools for Light Alloys. P. Kelle. Metallurgist (Supp to Engr) Mar 25, 1932 p 46–7. Machine tools of new and specialized types produced for use in machining aluminum alloys; outstanding feature is very high cutting speed for which provision is made, involving speeds approaching 5000 ft per min; machines are independently driven by electric motor; various types of bearings employed.

ALUMINUM ALLOYS

DURALUMIN. See *Duralumin.*

TITANIUM - ALUMINUM BRONZE. Discusses Manufacture of Titanium Aluminum Bronze. C. Vickers. Foundry v 60 n 5 Mar 1 1932 p 36–40. Search for suitable degasifier led to use of titanium, calcium, and magnesium in bronze; physical properties of test specimens.

AUTOMOBILES

DESIGN. Automobile Engineering Progress. A. M. Wolf. Soc Automotive Engrs J v 30 n 1 Jan 1932 p 1–15. General design and detail mechanical developments incorporated in automobile, truck, and motor-coach models for 1932; greater comfort; reduction of air resistance, noise, and weight; insulation against heat from engine; easier control; improved visibility; longer service life of some parts; avoidance of vapor lock; enhanced safety; increased operating economy.

MANUFACTURE. Workshop Practice in Automobile Engineering. H. Austin. Machy Market n 1636 Mar 11 1932 p 215–16 and 220. Line production and direct-feed type of layout; machine tool improvements; automatic chucking; die sinking and stamping; electric welding; valve production; Austin factory layout. Before Instn. Engrs. and Shipbldrs.

STREAMLINE. Development of Rear-Engined Streamline Car. D. Burney. Soc Automotive Engrs J v 30 n 2 and 3 Feb 1932 p 57–64 and (discussion) Mar p 116–19. Reference to unconventional designs produced in Europe and America, such as front-wheel-drive and rear-engined cars; elimination of nearly one-half air resistance of orthodox sedan and much steadier riding at high speed; analysis of forces and motions induced in car by location of center of gravity and distribution of weight.

TRANSMISSIONS. Synchronizing Gear Simplified in Muncie-Designed Transmission. P. M. Heldt. Automotive Industries v 66 n 12 Mar 19 1932 p 447–8. Design and operation of synchromesh type developed by Muncie Products Division of General Motors Corp., Muncie, Ind. and used on Pontiac and Oldsmobile cars; from car speed of 60 mph, shifting from high to intermediate ratio can be accomplished in maximum of 1.5 sec.

AUTOMOTIVE FUELS

VAPOR LOCK. Method for Determining Vapor Lock. C. K. Francis. Oil and Gas J v 30 n 44 Mar 17 1932 p 22. Definition of vapor lock or gas lock, ascribed to preheating of gasoline before delivery to engine cylinders; simple laboratory method for determination; road test.

BEARING METALS

PRESENT-DAY. Bearing Metals as Made and Used Today, C. H. Bierbaum. Iron Age v 129 n 13 Mar 31 1932 p 774–6 and 817. Review of essential facts regarding present-day bearing metals; emphasis placed on fact that hard and soft microscopic particles; intimately mixed, are necessary to insure satisfactory product; among improvements in bearing metals, nickel phosphor bronze outstanding; protest against improper tooling.

TIN-BASE. Effect of Crystal Size on Physical Properties of Tin-Base Babbitts, E. B. Drake. Metals and Alloys v 3 n 3 Mar 1932 p 77–81. Relations between hardness, compressed strength, and crystal structure; crystal size of babbitts cast into bearings can be controlled by casting and mold temperatures; hardness, as at present measured, is not function of crystal size in tin-base babbitts.

BEARINGS

FRICTION. Schmiertechnische Untersuchungen, O. Walger. VDI Zeit v 76 n 9 Feb 27 1932 p 205–8. Experimental determination and calculation according to hydrodynamic theory of friction coefficient for plain bearings show satisfactory agreement; investigation of limit of film lubrication for bearings with uniform and alternating load; synthetic lubricants without oil or grease content, give low friction coefficient.

LUBRICATION. Bearing Lubrication. Engineering v 133 n 3444 Jan 15 1932 p 80–1. Abstracts of two papers before Institution Civil Engineers, as follows: Distribution and Thickness of Oil Film in Flooded Cylindrical Bearings, J. Goodman; Stability of Lubricating Films in Journal Bearings, H. W. Swift.

Why Ball and Roller Bearings Require Lubrication, M. Reswick. Iron Age v 129 n 10 and 11 Mar 10 1932 p 608–10 and Mar 17 p 672–3 and (adv section) 20. Engineering analysis of ball and roller bearings together with author's conclusions relating to proper lubrication; properties of lubricants and their applications, including those for extreme pressure conditions, as in rolling-mill bearings.

BERYLLIUM ALLOYS

BERYLLIUM-COPPER. Wrought Beryllium - Copper for Electrical Parts and Springs, K. G. Frank. Product Eng v 3 n 3 Mar 1932 p 108. Further developments in wrought metals of new physical and electrical characteristics; springs of beryllium-copper alloys have been stressed 25,000,000 times without apparent fatigue while standard phosphor spring bronze failed after 400,000 compressions.

BLAST FURNACES

MODERN. Modern Blast Furnace, G. E. Butler. Iron and Coal Trades Rev v 124 n 3338 and 3339 Feb 19 1932 p 321 and Feb 26 p 364–6. Development of blast-furnace lines in United States; Continental large-output furnace; hearth jackets; furnace columns; tuyère housing, tuyères and bosh; shaft shell and belts; shaft-cooling plates; furnace-lining bricks, blast-furnace operation; British practice. Before Cleveland Inst Engrs.

BOILERS

DESIGN. Die Entwicklung der waermewissenschaftlichen Grundlagen des Dampfkesselbaus, H. Bonin. Archiv fuer Waermewirtschaft v 13 n 3 Mar 1932 p 57–62. Development of thermotechnical principles of boiler design; properties of steam; pressure and temperature in state of saturation; total heat; specific volume and heat; critical pressure and temperature; fuel and combustion process; calorific value; specific heat of flue gas; temperature measurement; heat transmission; gas radiation.

Neuzeitliche Dampfkesselberechnung, H. Dorfmann. Archiv fuer Waermewirtschaft v 13 n 2 Feb 1932 p 47–50. Modern methods of boiler calculation; need for simple method; *I-T* diagram; furnace temperature; cooling of flue gas; waste-gas losses; measurement of heating surface; examples for design calculation of new boiler and determination of temperatures with given heating surfaces.

EFFICIENCY METERS. Boiler Ratio Meters. World Power v 17 n 99 Mar 1932 p 206. Power-plant engineer interested in overall efficiency of boiler plant appreciates inclusion of continuous CO_2 determination as integral part of system, in boiler efficiency meters; model described provides accurate steam flow measurement, sensitive control of air supply, together with continuous check on combustion efficiency by fundamental system of CO_2 measurement.

FORCED DRAFT. Propeller Type Forced Draft Fans, W. R. Loveless. Power Plant Eng v 36 n 6 Mar 15 1932 p 244–5. Airplane-propeller fans replace conventional design and save 40 per cent of first cost, 25 per cent in power, and require but fraction of space; operating advantages of fans in service for two years in Western Electric plant, handling dust-laden air.

FURNACE REGULATORS. Selbsttaetige Feuerungsregler in Dampfkraftwerken, A. Heinig. Archiv fuer Waermewirtschaft v 13 n 3 Mar 1932 p 77–8. Automatic furnace regulators for steam power plants; comparison of operation with and without regulator; improvement in efficiency by use of regulator; results of tests.

HEADS. Vorschlaege zur Vereinfachung der Berechnung, Bewertung und Nach-Messung der Korbbogen - Woelbboeden, G. Hoennicke. Waerme v 55 n 7, 8 and 9 Feb 13 1932 p 97-102 Feb 20 p 118–21 and Feb 27 p 136–9. Recommendations for simplification of calculation, evaluation and subsequent measurement of basket-shaped dished heads; simple approximate formulas are derived for main dimensions of actual meridians; calculation of thickness.

HIGH-PRESSURE. High-Pressure Boiler Design in Europe, C. J. Webb. Power Plant Eng v 36 n 7 Apr 1 1932 p 289–90. Cascade-injection boiler for quick regulation on peak loads; sectional elevations of Brown-Boveri boiler; design and testing details.

NATURAL-GAS. Natural Gas-Fuel for Power, J. B. Nealey. South Power J v 50 n 3 Mar 1932 p 17–19. Particularly significant in expansion of natural gas piping has been availability of this fuel for steam generation; details of Long Beach plant of Southern California Edison Co., which receives natural gas through 26-in. diam pipe lines from Kettleman Hills, which is 213 mi distant; natural gas-fired boiler construction and operation.

NEW TYPES. Neuere Dampfkesselbauarten, F. Schulte. VDI Zeit v 76 n 10 Mar 5 1932 p 217–25. Variety of boiler designs emphasizes need for standardization, particularly in Germany; bases for ordering and operation of boilers with particular regard to safety and economy; examples of utilization of modern research results on boilers of simple construction.

WELDING. Die autogene Schweissung von langen Kesseln, C. F. Keel. Zeit fuer Schweisstechnik v 21 n 12 Dec 1931 p 286–90. Procedure in welding of long boilers and tanks; preparation of seams for welding.

BRASS

HOT PRESSING. Hot-Pressings of Brass, J. D. Speakman. Metal Industry (Lond) v 40 n 3 Jan 15 1932 p 97–100. Operations involved and presses employed for process of hot pressing in brass and other non-ferrous metal alloys; furnaces; power presses; material for dies; uses of hot brass pressings; advantages over castings.

CARS

FREIGHT—ALUMINUM HOPPER. Alumnium Placed on Trial in Hopper Cars. Ry Age v 92 n 13 Mar 26 1932 p 516–18. Alcoa Ore Co. buys ten 70-ton aluminum cars from Canton Car Co.; average physical properties of aluminum alloys; details of car body and underframe construction.

CASE HARDENING

CARBURIZING. Testing for Efficiency in Carburizing Methods, D. W. Frye. Iron and Steel Canada v 15 n 1 Jan 1932 p 4–5. Comparison of carburizing results of gas and pack methods; S.A.E. 3120 steel, carburized respectively in rotary retort carburizing furnace using natural gas, and in carburizing box using solid compound; heat maintained at 1750 F; time for penetration 14 hr in gas furnace, as compared to 20 hr in pack furnace.

CAST IRON

PROPERTIES. Ueber die Kerbempfindlichkeit von Gusseisen bei Beanspruchung auf Biegung, F. Roetscher. Maschinenbau v 11 n 4 Feb 18 1932 p 79–80. Test results show susceptibility of cast iron to notch effects under bending stresses; stress-distribution diagram illustrates causes.

TESTING. Caractérisation des propriétés mécaniques des pièces moulées in fonte grise, A. Portevin. Revue de Métallurgie v 29 n 2 Feb 1932 p 61–73. Study of mechanical properties of iron castings; factors determining choice of testing methods; criticism and improvement of methods for testing cast iron; conclusions based on author's studies since 1927; development and use of new methods, and future prospects. Bibliography. Before Int Congress Testing Matls, Zurich.

CASTINGS

FLUIDITY. Practical Method for Studying Running Quality of Metal Cast in Foundry Moulds, C. M. Saeger, Jr. and A. I. Krynitsky. Metal Industry (Lond) v 40 n 6 and 7 Feb 5 1932 p 171–4 and Feb 12 p 197–9. Tests conducted for aluminum, brass, and cast iron; metals cast in dry-sand molds ran further than those in green-sand molds; with increase in pouring temperature, length of test specimens increased in direct proportion to pouring temperature.

CHROMIUM-IRON ALLOYS

MANUFACTURE. Defirust. Engineer v 153 n 3974 Mar 11 1932 p 293, figs on p 288. There has been started in Darlington, England, works for production of iron-chromium alloys, by Darlington Rustless Steel and Iron Co.; policy of company is to produce only ingots of stainless metal and to pass them on to others for conversion into useful sizes; there has been installed electric furnace capable of producing from 10 to 12 tons of metal per melt; Wild process used.

NEW TYPE. New Rustless Iron Alloy, R. P. De Vries. Metals and Alloys v 3 n 2 Feb 1932 p 49–51. Properties of alloy containing 0.10 per cent max carbon; about 16 per cent chromium; 1 per cent silicon; 1 per cent copper; 0.40 per cent manganese; max. phosphorus and sulphur, 0.03 per cent; data on hot and cold working, soldering and brazing, welding, riveting, scale removal, grinding and polishing, and heat treatment.

CHROMIUM-NICKEL ALLOYS

ILLIUM. New Metal for Instruments, W. D. Staley. Instruments v 5 n 3 Mar 1932 p 65 and A22. Illium is alloy composed principally of nickel, chromium, copper, molybdenum, and tungsten, with smaller amounts of other metals; it has found greatest use to date in places where severe corrosive conditions are encountered, such as filter parts, agitators, nozzles, etc; it is ideal material, however, for many instrument parts; properties.

COAL

CALORIFIC VALUE. Calorific Values of Fuel by Calculation, E. L. Johnson. Colliery Eng v 9 n 97 Mar 1932 p 87. Rapid, reliable, and simple method of calculating actual calorific value of any fuel from usual commercial analysis.

CARBONIZATION, LOW-TEMPERATURE. Salerni System of Low-Temperature Carbonisation, E. Salerni. Engineer v 153 n 3972 Feb 26 1932 p 243–4. Process consists in heating to temperature of 450 C by external application of heat, in retort of revolving-drum type, blend of comminuted coal and semi-coke, so finely ground that its porous structure is destroyed, pitchy fractions of oil from process itself being added to blend; application to treatment of non-coking coals even when coking coals are not available for blending with them. Before Third Int Conference on Bituminous Coal 1931.

PULVERIZERS. High - Capacity Coal Pulverizers at Kips Bay Station, P. Cassidy. Power v 75 n 10 Mar 8 1932 p 380–1. Construction and operating details of coal-preparation plant extension in Kips Bay Station of New York Steam Corp. Before Am. Soc. Mech. Engrs.

CONVEYORS

BELT. Coal, Clay and Sand Handling by Steel Band Conveyors. Eng and Boiler House Rev v 45 n 9 Mar 1932 p 585–7. Details of combined steel conveying system which handles 60 tons of coal, 40 tons clay, and 40 tons of wet or dry sand per hr.

COPPER ALLOYS

COPPER - SILICON. Everdur Metal — High Strength, Corrosion Resistant Engineering Material, C. B. Jacobs, Jr. Metals and Alloys v 3 n 1 Jan 1932 p 26. For sand castings metal contains 94.3 per cent copper, 4.5 per cent silicon and 1.2 per cent manganese; for wrought forms, 96 per cent copper, 3 per cent silicon, and 1 per cent manganese; strength and fatigue limit are comparable to those of steel; metal developed by du Pont Co.; industrial applications.

P. M. G. ALLOY. P. M. G. Alloy, W. Machin. Metal Industry (Lond) v 40 n 7 Feb 12 1932 p 201–2. New Alloy manufactured by Vickers Armstrong, who hold patent rights; physical properties of P. M. G. metal in form of castings, and covering range governed by percentage of constituent hardener, and temperature at which metal is worked; alloy is composed of 89.6 per cent copper, 4.24 per cent silicon, small percentages of iron and manganese, and remainder zinc.

PROPERTIES. Properties of Copper in Relation to Low Stresses—Effect of Cold-Work, Heat-Treatment, and Composition—I, O. F. Hudson and J. McKeown. Inst Metals—Advance Paper n 594 mtg Mar 9–10 1932 20 p. Tensile and compression tests under short-time loading; results show superior resistance to deformation brought about by cold work and suitable heat-treatment, and greater resistance to deformation conferred on copper, by presence of very small percentage of silver, tin, and silicon.

Properties of Copper in Relation to Low Stresses—Effect of Cold-Work, Heat-Treatment, and Composition—II, H. J. Tapsell and A. E. Johnson. Inst Metals—Advance Paper n 599 mtg Mar 9–10 1932 6 p. Creep tests at 300 and 350 C of arsenical and silver arsenical copper; improvement in resistance to creep at these temperatures is effected by special pretreatment of alloys, and alloys containing 0.072 per cent silver are superior to silver-free alloys.

TESTING. Physical Testing of Copper and Copper-Rich Alloys in Form of Thin Strip, M. Cook and E. C. Larke. Inst Metals—Proc v 46 n 2 1931 p 245–61 and (discussion) 61–6. Tensile, hardness, and cupping tests using various types of machines were carried out on H. C. copper, 95:5 copper-zinc alloy, 70:30 and 64:36 brass, and 80:20 cupro-nickel in form of strip, 0.06, 0.04, 0.02, and 0.01 in. in thickness prepared in accordance prevailing commercial practice.

CRANES

POWER-PLANT. Power House Cranes. Nat Elec Light Assn—Proc v 87 mtg June 16–20 1930 p 634–9. Hydraulic Power Committee report is intended to cover cranes used in substations as well as power houses; methods of reducing headroom requirements; economic factors affecting crane selection, speed of operation, motor-type torque and horsepower requirements, bridge and trolley structural design, gearing, brakes, and wheels, etc.

CRANK DRIVE

KINEMATIC ANALYSIS. Die Ableitung einer Hubbewegung mit drei Stillstaenden von Koppelkurven; K. Rauh. VDI Zeit v 76 n 4 Jan 23 1932 p 87–90. Kinematic analysis of oscillating crank drive with three positions of rest.

CUTTING TOOLS

SKIVING TOOLS. Designing Skiving Tools for Formed Parts, J. L. Ingalls. Machy (NY) v 38 n 7 Mar 1932 p 507–11. Methods of laying out skiving tools for accurately finishing formed parts through application of shaving-shearing cut.

TUNGSTEN CARBIDE. Tantalum Binder Improves Quality of Hard Cutting-Tool Alloy, T. H. Gerken. Iron Age v 129 n 10 Mar 10 1932 p 600–1. Development of new cutting-tool hard alloy, made up of stronger tungsten-carbide particles held in tantalum-tungsten-carbon and cobalt binder and intended to eliminate cratering and other difficulties of hard alloy tools when used on steel.

DIE-CASTING MACHINES

PRESS CASTING. Press Casting, C. Pack. Metals and Alloys v 3 n 2 Feb 1932 p 29–37. Development and application of principal types of die-casting machines and processes; plunger-type die-casting machine; air or goose-neck-type die-casting machine; Jaquemont principle of press casting; Polak press-casting machine; Pack type of press-casting machine.

DIESEL ENGINES

AUTOMOTIVE. Air Capacity and Speed of Diesel Engines as Basis for Appraising Automotive Characteristics, J. Kuttner. Diesel Power v 10 n 2 Feb 1932 p 73. Experimental determination of carbon dioxide percentages in exhaust gases as basis for calculating air quantities actually passing through engine; brake mean effective pressure fails to distinguish between losses due to low volumetric efficiency and losses due to imperfections in combustion. Abstract of paper before Soc Automotive Engrs.

Commercial Application of Diesel Engines in Heavy-Duty Motorcoaches and Trucks, G. A. Green. Soc Automotive Engrs—J v 30 n 2 Feb 1932 p 65–75 and (discussion) 75–9. Comparative tests both on block and in motor-coach chassis, of 525-cu in. gasoline and 495-cu in. Diesel engine; costs of manufacture and maintenance and present and prospective conditions as to supply and cost of Diesel fuel; lower torque per unit of displacement would make necessary Diesel engine having more cylinders than gasoline engine.

Heavy-Oil Engine for Tail Traction, B. Reed. Ry Gaz v 56 n 13 Mar 25 1932 p 468. General survey of various types of Diesel engines for railroad work; tabular review of ten standard engine specifications.

BABCOCK & WILCOX. New Babcock Heavy-Oil Engine. Gas and Oil Power v 27 n 318 Mar 1932 p 69–71. Horizontal cold-starting airless-injection engine of improved design; series of engines is projected, ranging from 35–85 bhp in single cylinder types, and 100–170 bhp where twin engines are required; engines are designed to run at speeds varying from 350–250 rpm, according to size; operating and constructional details.

COMBUSTION IN. Apparatus for Study of Diesel Engine Combustion. A. M. Rothrock. Instruments v 5 n 3 Mar 1932 p 61–4. Results obtained with N.A.C.A. equipment designed for photographic investigation of spray formation and combustion under conditions which closely simulate those in combustion chamber of compression-ignition engine; air velocities of about 300 fps are necessary to destroy core of spray. Before Soc Automotive Engrs.

CONNECTING RODS. Diesel Connecting-Rod Stresses, O. Thorncroft and B. C. Carter. Aircraft Eng v 4 n 37 Mar 1932 p 69–70. Theoretical analysis of impact effects due to rapid rise of cylinder pressure; ratio of maximum force in connecting rod to maximum force on piston plotted on base of natural periods of vibration.

FUEL INJECTION. Effect of Reservoir Volume on Discharge Pressures in Injection System of N.A.C.A. Spray Photography Equipment, A. M. Rothrock and D. W. Lee. Nat Advisory Committee Aeronautics—Tech Notes n 407 Feb 1932 9 p 7 supp plates. Data show that injection system can be designed so that not more than full-load fuel quantity can be injected into engine cylinders, and so that fuel-spray characteristics remain constant over large range of engine speeds; formulas for computing volume of reservoir and diameter of discharge orifice.

Experiments on Distribution of Fuel in Fuel Sprays, D. W. Lee. Nat Advisory Committee Aeronautics—Tech Notes n 410 Mar 1932 14 p 15 supp plates. Photographic study of sprays injected into evacuated chambers, into atmosphere, into compressed air, and into transparent liquids; pairs of identical sprays were injected counter to each other; results showed that distribution was very uneven; shape of central core varies with density of air, becoming shorter and thicker with increasing air density.

Preliminary Tests on Vaporization of Fuel Sprays, A. M. Rothrock. Nat Advisory Committee Aeronautics—Tech Notes n 408 Feb 1932 4 p 4 supp plates. Investigation of ethyl alcohol, gasoline, and fuel oil shows that sprays vaporize appreciably so that it is possible for ignition in high-speed compression-ignition engines to take place from vapor phase.

HIGH-SPEED. What Is High-Speed Diesel? V. L. Maleev. Power v 75 n 14 Apr 5 1932 p 512–13. Method of classifying oil engines into low-, medium-, high- or super-high-speed classes by means of speed characteristic which is equal to piston speed times revolutions per minute divided by 100,000; chart for determining engine speed classification based on piston speed and rpm.

INDICATORS FOR. Two New Diesel Indicators. Gas and Oil Power v 27 n 318 Mar 1932 p 67–8. Dobbie McInnes & Clyde, Ltd., Glasgow, have introduced large-diagram indicator and new continuous time - base - diagram instrument; operating features; characteristics of improved Diesel-Engine indicator valve.

DURALUMIN

PROPERTIES. Untersuchung von Duralplatblechen, K. Schraivogel and K. O. Schmidt. Zeit fuer Metallkunde v 24 n 3 Mar 1932 p 57–62 (discussion) 59–62. Results of Tests on "Duralplat" (duralumin plates), made by Duerener Metallwerke, Germany; tensile strength and 0.2 elastic limit are 5 to 10 per cent lower than for standard duralumin; bending properties are about same, Erichsen values lower; only protective layer is corroded; under conditions employed in tests, corrosion resistance was greater than that of ordinary duralumin.

ECONOMIZERS

PROTECTION. Ekonomiserschutz gegen Wassermangel und Wasserschlaege, F. Wenge. Archiv fuer Waermewirtschaft v 13 n 2 Feb 1932 p 37–8. Protection of economizers against water shortage and water hammer; causes of economizer damages; development of protective device with automatic steam blow-off and subsequent filling with water.

ELECTRIC WELDING

[See *Welding.*]

ENGINEERING UNITS

GRAPHICAL EXPRESSION OF. Graphische Darstellung von Mass-Systemen, H. Wueger. Assn Swisse des Electriciens—Bul v 22 n 26 Dec 26 1931 p 637–40. Attempt to express dimensions of quantities in cgs system by means of system of three-dimensional coordinates in order to obtain simplification.

FANS

DRAFT. Fans for Mechanical Draught Purposes. World Power v 17 n 99 Mar 1932 p 208. Specific types of fans for mechanical purposes are now manufactured to meet varied requirements of modern boiler houses and engine rooms; working conditions of these fans and considerations affecting their design.

FLOW OF FLUIDS

ALIGNMENT CHARTS. Nomogramme in der Stroemungstechnik. H. Richter. Gas - und Wasserfach v 75 n 8 Feb 20 1932 p 141–4. Construction of four alignment charts for computation of Reynolds' number for water and air flow, also loss of head in straight pipe lines; charts are applicable to compressible and non-compressible liquids, also gases and vapors.

FLOW OF GASES

DIAPHRAGMS. Die Stroemung von Gasen durch Blenden, W. Nusselt. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 1 Jan–Feb 1932 p 11–20. Theory of similarity for gas flow through pipes, diaphragms and nozzles for considerable pressure drop along direction of flow; one dimensional theory for flow through diaphragm considering radial velocity components; satisfactory agreement of experiments and theory for low and high pressure; pressure ratio of 0.245 for air flow through diaphragm.

MEASUREMENT. Measurement of Flow of Gases and Vapors, B. F. Dodge. Indus and Eng Chem v 24 n 3 Mar 1932 p 261–73. Review of modern methods for continuously measuring and recording gas flow which are in extensive use in industry; term "gas" is understood to include condensable vapors, such as steam, but discussion refers more specifically to gases that are not condensed at ordinary atmospheric conditions. Bibliography.

FLOW OF WATER

RUBBER HOSE. Frictional Pressure Drop in Rubber-Lined Hose. Chem & Met Eng v 39 n 3 Mar 1932 p 132. Experiments carried out by B. F. Goodrich Rubber Co., have resulted in derivation of table for frictional pressure drop encountered in flow of water through rubber-lined hose and pipe; so far as is known, this is first time these data have been available.

FORGING

BRASS. See *Brass—Hot Pressing.*

PRESSES FOR. Forging Presses, E. Reinecke. Eng Progress v 13 n 3 Mar 1932 p 70–2. Forging press shown is of 600 tons capacity with 200-ton side press, for shearing, trimming, blanking, and other operations; built to meet special requirements of overseas customer by Henry Pels & Co. A. G., Berlin; principal dimensions of machine are ram surface 3.2 by 2–45 ft; table surface 4 by 2.8 ft; distance between ram and table at top of stroke 2.3 ft; stroke 0.85 ft.

FURNACES, MELTING

OIL-FIRED. Design of Oil-Fired Crucible Furnaces, G. S. Watson. Foundry Trade J v 46 n 809 Feb 18 1932 p 117 and 120 including discussion. Principles of oil-fired crucible furnace construction with particular regard to burner, oil-blast inlet, combustion chamber, metal preheating chamber, and waste products outlet.

GAGES

INTERCHANGEABLE-PART PRODUCTION. Messgeraete und-verfahren fuer den Austauschbau, G. Berndt. VDI Zeit v 76 n 10 Mar 5 1932 p 241–7. Measuring instruments and methods for production of interchangeable parts; gages, mechanical and optical feelers, micrometers, measuring machines and comparators; measuring of angles and degree of tapering, dividing heads, etc.; screw-thread measuring equipment; measurement of gear teeth.

SURFACE. Test for Smoothness of Machined Surfaces, F. A. Firestone, F. M. Durbin and E. J. Abbott. Metal Progress v 21 n 4 Apr 1932 p 57–9. Surface is traversed with fine tracer point connected with small mirror so that movements of tracer produce angular displacements of mirror recorded on moving photographic paper, developed at University of Michigan; irregularities in graph of order of 0.10 in. correspond to 0.00035 in. on gear tooth.

GEARS

INVOLUTE. Interference in Internal Involute Gears, F. W. Shaw and H. Shaw. Am Mach v 76 n 11 and 12 Mar 17 1932 p 363–6 and Mar 24 p 396–401. Determination of minimum tooth difference or numbers of teeth in pair of involute internal gears so that, when internal diameter of gear has been enlarged (where necessary) to obviate involute interference, points of pinion's teeth shall not foul points of wheel's teeth as these pass out of engagement; interference limits for 14½-deg internal gears.

NON - METALLIC. Unitex - Hartqewebe, ein neuer Werkstoff fuer Zahnraeder im modernen Maschinen- und Apparatebau. Kunststoffe v 21 n 12 Dec 1931 p 269–71. Manufacture, properties, and machining of Unitex hard fabric, new material for gears in modern machine and apparatus construction; it is compound of best

special fabric with synthetic resin compressed under high hydraulic pressure and heat.

WORM. Schneckengetriebe fuer aussetzenden Betrieb, G. Schiffner. Foerdertechnik und Frachtverkehr v 25 n 5–6 Mar 11 1932 p 51–3. Worm gears for intermittent operation; calculation for allowable side pressure and heating; values are higher than for continuous operation.

GRINDING MACHINES

IRREGULAR SURFACES. Ein originelles, neues Verfahren zur Herstellung von Werkzeugen unregelmaessiger Formen, Schlippe. Maschinen Konstrukteur v 65 n 1–2 Jan 10 1932 (Werkzeug) p 1–4. Design and operation of grinding machine built by Seidel and Naumann, Dresden, incorporating pantograph mechanism for grinding irregular surfaces and shapes particularly of tools and dies.

TUNGSTEN CARBIDE CUTTING TOOLS. Grinding Machine for Widia Tools Engineer v 153 n 3973 Mar 4 1932 p 270 Machine, specially designed by B. R. Rowland and Co. in conjunction with A. C. Wickman, Ltd., is equipped with three grinding wheels, one for roughing, one for finishing and one for polishing to remove any trace of saw-tooth edge, as seen under microscope.

HAMMERS

DROP. Beche Drop-Hammer, H. Beche. Eng Progress v 13 n 3 Mar 1932 p 67–8. New hammer which avoids drawbacks of both board and steam drop hammers made by Beche & Grohs G.m.b.H., Germany; striking frequency varies from max of 70 to 80 blows with heaviest hammers to 100 in smaller models: energy of blow is 820 ft-lb per 100 lb.

HEAT ENGINEERING

FLOW OF FLUIDS. Stroemungsforschung und praktische Waermewirtschaft, M. Hansen and K. Jaroschek. VDI Zeit v 76 n 8 Feb 20 1932 p 169–72. Review of research in hydraulics and aerodynamics of pulverized-coal firing installations, draft, steam turbines and condensers, dust precipitation, etc; use of hydraulic models; theoretical principles of model testing. Bibliography.

HEAT-INSULATING MATERIALS

TESTING. Thermal Conductivity of Low Temperature Insulators, N. H. Chamberlain. Soc Chem and Industry—J (Trans and Communications) v 51 n 11 Mar 11 1932 p 89T–91T. Apparatus used by author was designed primarily for use with textile materials, but could readily be extended to measurement of other granular and fibrous materials; principle on which it is based is to use as means of small heat quantities, contraction which occurs when ice at 0 deg melts into water at same temperature.

HYDRAULIC DRIVE

TYPES. Various Methods of Hydraulic Drive. Hydraulik Rev v 2 n 1 1932 11 p. Operating principles and industrial application of principal types of hydraulic drive including purely hydraulic drive, electro-hydraulic, steam-hydraulic, and air-hydraulic operation; data on power consumption.

HYDRAULIC MACHINERY

PACKING. Packungen und Manschetten fuer hohen hydraulischen Druck, H. Sondermann. Maschinen Konstrukteur v 64 n 23–24 Dec 10 1931 p 231–4 and v 65 n 1–2 Jan 10 1932 p 8–9. Dec 10: Design of packings and gaskets for high hydraulic pressures. Jan 10: Dimensions of packing of convex or concave type suitable particularly for double-acting pistons.

HYDRAULIC TURBINES

CAVITATION. Cavitation of Hydraulic Turbine Runners. Engineering v 133 n 3454 Mar 25 1933 p 366–7. Runners of 52,000-hp machines in Queenston power house, Ontario; pitted areas are repaired by electric welding; after chipping out pitted metal, new is built up layer by layer, using soft iron for underlying layer, and flux-coated steel rod, of 60,000 lb per sq in. ultimate strength, for surface.

TESTS. Versuche an den hydraulischen Maschinen des Kraftwerkes Waeggital. Schweiz Bauzeitung v 99 n 7 and 9 Feb 13 1932 p 86–90 and Feb 27 p 107–119. Report on acceptance tests of hydraulic turbines of Siebnen and Rempen hydroelectric power plants, also of centrifugal pumps of Rempen hydroelectric plant; turbines were tested for heads up to 200 m by means of current meters and sharp crest weirs; pumps were tested for heads in excess of 260 m and discharges up to and exceeding 1350 liters per sec.

HYDROELECTRIC POWER PLANTS

OREGON. Ariel Hydro Development, A. C. Clogher and W. S. Merrill. Elec World v 99; n 10 Mar 5 1932 p 442–6. Ariel, containing one 45,000-kw hydroelectric unit, is first plant in vicinity of Portland, Ore., having reservoir capacity for seasonal storage and low-load-factor operation; plant was built for Inland Power & Light Co., and is located on Lewis River; largest overhung generator and outdoor power house crane; arch dam 313 ft high.

PENNSYLVANIA. Highest - Powered Kaplan Turbines Installed at Safe Harbor. Power v 75 n 11 Mar 15 1932 p 391–5. Safe-harbor hydroelectric plant of Safe Harbor Water Power Corporation will have initial installation of six 42,500-hp automatically adjusted-blade propeller-type turbines to operate under 55-ft head; provisions are made in design for six additional units making ultimate capacity 510,000 hp; unit discharge of 9000-sec-ft at full load.

IMPACT TESTING

NOTCHED-BAR. Zur Normung des Kerbschlagversuches, M. Moser. VDI Zeit v 76 n 11 Mar 12 1932 p 257–61. Establishment of bases for standardization of impact test samples; suggestion of specimen with rounded notch for main tests and specimen with pointed notch for supplementary tests; possibilities of international standardization.

INDUSTRIAL MANAGEMENT

BUDGET CONTROL. Die Wirkung der Unkosten-Budgetierung in der Krisenzeit, E. Haverbeck. Werkstattstechnik v 26 n 5 Mar 1 1932 p 109–12. Budget-control system used by L. Schuler A.-G.-Goeppingen, Germany with date for 1928, 1929, and 1930; graph shows relation between cost and operating ratio.

COST ACCOUNTING. "Normal" Cost—Key to Stable Overhead Charges, T. B. Frank. Iron Age v 129 n 13 Mar 31 1932 p 765–7. Determination of normal basis for charging overhead to costs; applying charge in flush times will result in building up overhead reserve in excess of normal requirements and applying it in dull periods will result in overhead deficits which will be deducted from reserve; author states that overhead expenses should not include cost of carrying excess capacity.

INVENTORY CONTROL. Inventory Control, C. B. Stiffler. Soc Automotive Engrs J v 30 n 1 Jan 1932 p 46–9 and (discussion) 49–52. Comparison of trends in inventory control from 1920 to 1930; monthly forecast based on 10-day reports from dealers of stocks and actual and estimated sales; charts show inventory investment and inventory turnover of General Motors Corp from 1920 to 1931.

MAINTENANCE CONTROL. Simple Maintenance Control, A. G. Suttill. Factory and Indus Mgmt v 83 n 3 Mar 1932 p 113–5. Practical outline of time study for maintenance of efficiency; time alottment for practically any maintenance job; analysis of items of time study.

PRODUCTION CONTROL. Grafische tepaling van rentabiliteit, D. C. Van Schaik. Polytechnisch Weekblad v 26 n 8 Feb 25 1932 p 120–1. Graphic method by which information may be obtained of various points in production process in simple manner and which may be applied to various forms of production.

Aufgaben und Organisation eines Arbeitsbueros im Walzwerk, O. Beyer and P. Zahn. Stahl und Eisen v 52 n 8 Feb 25 1932 p 181–7 and (discussion) 187–9. Functions and organization of engineering department in rolling mill; disadvantages of present organization systems; functions of engineering department are enumerated and discussed individually; cost estimating dimension of work, etc.

TIME STUDY. Sinnbilder fuer Arbeitsgaenge in der Airbetszeitermittlung, L. Boettcher. Maschinenbau v 11 n 4 Feb 18 1932 p 73–5. Symbols for principal machining operations and their use in records for shop procedure and time study purposes.

Time Studies and Group Bonus, T. G. Laufer. Factory and Indus Mgmt v 83 n 4 Apr 1932 p 164–5. Outline of time and study motions which preceded installation of standard-rates in automatic screw machine dept in plant manufacturing electrical equipment.

INDUSTRIAL RESEARCH

EXPENSE, CONTROL OF. Control of Research Expense, W. A. Hamor and G. D. Beal. Indus and Eng Chem v 24 n 4 Apr 1932 p 427–31. Apportionment of research expense in industrial management; budgeting of research expense; procedures of research control.

TRAINING PERSONNEL. Selection and Training of Industrial Research Personnel, W. N. Jones. Indus and Eng Chem v 24 n 4 Apr 1932 p 423–7. Factors in selection of research workers; university training; factory training.

INTERFEROMETERS

HILGER. Hilger Gauge - Comparing Interferometer. Engineering v 133 n 3455 Apr 1 1932 p 412–13. Double interferometer, designed primarily for use in constructing Williams reflection echelon, but equally applicable for testing gages.

INTERNAL-COMBUSTION ENGINES

COMBUSTION. Study of Combustion Process, L. C. Lichty, R. R. Faller and M. F. Smith. Soc Automotive Engrs J v 30 n 2 Feb 1932 p 101–4. Determination of pressure for any instant of cycle with knowledge of compression pressure and temperature, and of heat loss from both burned and unburned portions; studies of both effect of dilution with exhaust products and of heat loss from unburned portion of mixture; effect of initial temperature and heat loss from burned portion upon flame-front position.

FUEL INJECTION. Further Investigation of Fuel Injection in Engine Having Spark Ignition, E. S. Taylor and G. L. Williams. Soc Automotive Engrs—J v 30 n 1 Jan 1932 p 24–9 and (discussion) 29–30. Investigation in aeronautic-engine laboratory of Massachusetts Institute of Technology; $3^1/_4$ by $4^1/_2$-in. Cooperative-Fuel-Research engine; effects of stratification and of late injection or late ignition as means of controlling detonation with high compression; fuels used were aviation gasoline, ordinary Diesel fuel and hydrogenated fuel oil.

TURBULENCE. Turbulence in Combustion Chambers, A. E. L. Chorlton. Engineering v 133 n 3450 Feb 26 1932 p 237–8. Contribution to problem of turbulence in internal combustion engines; author's experiences in development of high-speed engines for airship R. 101; types of turbulent chambers.

[See also *Airplane Engines; Diesel Engines; Oil Engines.*]

LOCOMOTIVES

DIESEL. Sleeve-Valve Diesel Engines for Rail Traction. Ry Gaz v 56 n 13 Mar 25 1932 p 464–5. Design and constructional details of Mirrless-Ricardo high-speed Diesel engines for rail traction; diagrams illustrating design features; operating characteristics.

DIESEL-ELECTRIC. All Welded Switching Locomotive, R. V. Devlin. Gen Elec Rev v 35 n 2 Feb 1932 p 110–12. Seven 60-ton 300-hp Diesel-electric locomotives for switching service at Bush Terminal, New York City, completed at Erie plant of General Electric Co.; mechanical portion, including cab, underframe, and trucks, is fabricated entirely from structural-steel shapes and plates and arc welded throughout; there are no rivets, and bolts are used only for portions requiring occasional removal or renewal.

Operating Economies of Diesel-electric Locomotives, R. D. Krape. Gen Elec Rev v 35 n 3 Mar 1932 p 178–80. Items of expense of Diesel-electric and of steam locomotives; comparative data of locomotives in industrial-plant service; in railroad switching service.

Operation of New York Central Three-Power Locomotives, W. S. H. Hamilton. Ry Elec Engr v 23 n 3 Mar 1932 p 60–3. Batteries supply 15 per cent of energy required, by motors; engines use only 9.5 gal of fuel per hr; locomotives available or service 85 per cent of time; locomotive requirements; characteristics of three-power locomotives; locomotive performance.

DIESEL VS. STEAM. Oil-Engined Locomotives Versus Steam. Engineer v 153 n 3971 and 3973 Feb 19 1932 p 213 and Mar 4 p 268. Feb 19: Editorial comment on status of British railroads; writer suspects that assault upon steam locomotive is not completely disinterested; oil engine locomotive would cost approximately twice as much as steam engine of similar power. Mar 4: Comments, by C. J. H. Krutch on above editorial; he suggests that for main-line operation of freight, oil-engined locomotive is one in which great savings can be made.

ELECTRIC. Elektrische Eilgueterzug-Lokomotive Bo-Bo, W. Genschow. Elektrotechnische Zeit v 53 n 12 Mar 24 1932 p 281–4. Cross-sectional illustration and details of German express-freight electric locomotive Bo-Bo; 4200 hp at 58 km per hr; tractive power 19,600 kg; max speed 80 km per hr; length 13.5 m; weight 40 kg tons.

GASOLINE-ELECTRIC. Sixty-Ton Gas-Electric Locomotive Tested on Burlington. Ry Age v 92 n 14 Apr 2 1932 p 559–60. Demonstrated capacity to break up freight train in classification yard or handle mixed train in road service; details of test runs; characteristics of locomotive truck construction; power plant design and construction.

TESTING. Lehigh Valley Tests 4-8-4 Type Locomotives, F. E. Lyford. Ry Age v 92 n 12 Mar 19 1932 p 469–72. Locomotives Nos 5100 and 5200 each demonstrate ability to produce $80,000 more revenue annually than locomotives

now in use; profile of district over which tests were run; comparison of principal dimensions and proportions of locomotives tested and those in comparative service; tabular comparison of performance averages on test runs.

LUBRICATION

BEARINGS. Journal Friction With Boundary Lubrication—II, G. F. Nordenhalt and H. Chase. Product Eng v 3 n 3 Mar 1932 p 109–11. Bearings and their lubricating means give minimum friction losses when combination of lubricant viscosity, unit bearing pressure, and speed is such that unstable condition bordering on failure is approached; review of characteristics of simple lubricating devices.

MACHINERY. Le graissage des mécanismes frottement a sec, frottement onctueux, frottement visqueux, rainures de graissage, P. Mercier. Associations Françaises de Propriétaires d'Appareils a Vapeur—Bul v 13 n 47 Jan 1932 p 1–26. Lubrication of machinery, i.e., dry and oil friction; viscous friction; lubricating grooves; curves showing viscosity of oils for various types of engines and motors; complete discussion of entire field of axle lubrication and systems.

MACHINE TOOLS

AIR BRAKES FOR. Air Brakes on Machine Tools, L. J. Berkeley. Machy (N. Y.) v 38 n 7 Mar 1932 p 481–5. Design and operation of air brakes installed on drilling machines and lathes with individual electric drive.

GERMANY—DESIGN. Deutsche Grosswerkzeugmaschinen fuer spanabhebende Bearbeitung, A. Wallichs. VDI Zeit v 76 n 10 Mar 5 1932 p 248–56. Design of representative types of large-size machine tools including lathes, boring and milling machines, gear cutting machines, grinding machines, etc.; résumé of research work on chip removal with nomographs permitting simple determination of feed and speed on basis of hardness and tensile strength.

MAGNESIUM ALLOYS

ELEKTRON - MACHINING. Machining Magnesium Alloy Elektron. Machy (N. Y.) v 38 n 7 Mar 1932 p 532–3. Physical properties, characteristics, fields of application, and methods of machining elektron alloys; sketches illustrate forms of typical cutting tools for milling and turning.

METAL CUTTING

FORCE MEASUREMENT. Neuere Messverfahren fuer Werkzeugmaschinen, E. Sachsenberg and W. Osenberg. VDI Zeit v 76 n 11 Mar 12 1932 p 262–8. Equipment for measuring forces exerted during cutting process, based on mechanical, optical, and electrical, principles, developed at Technical University of Dresden.

METALS

CLEANING. Degreasing Metals by Vapor Process, E. V. D. Wallace. Metal Industry (N. Y.) v 30 n 2 Feb 1932 p 53–5 including discussion. Process for positive removal of heavy oils and greases; only pure solvents ever come in contact with degreased surface and, therefore, method is positive and not dependent upon operator; total cost is as low as $1 per ton.

CREEP MEASUREMENT. Accelerated Test for Determination of Limiting Creep Stress of Metals, W. Barr and W. E. Bardgett. Engineering v 133 n 3451 Mar 4 1932 p 293–4; see also Engineer v 153 n 3972 Feb 26 1932 p 241–2. In test devised by authors, procedure adopted eliminates searching, and enables stress value to be obtained in 48 hr; representative limiting creep stress values obtained by this test for variety of steels; small amounts of molybdenum have pronounced effect in raising limiting creep stress of low-carbon steels. Before Instn Mech Engrs.

DEFORMATION. Experimentelle Untersuchungen ueber die Abhaengigkeit der Zugspannungen von der Verformungsgeschwindigkeit, H. Deutler. Physikalische Zeit v 33 n 6 Mar 15 1932 p 247–59. Review of literature on experimental studies of relation between tensile stresses and speed of deformation of metals; also report on original experimental study of same problem made at laboratory of Applied Mechanics of University of Goettingen, using iron and copper as materials tested.

Plastic Deformation in Theory and Experiment, E. Siebel. Metallurgist (Supp to Engineer) Feb 26 1932 p 22–24. Survey of present position and of more important researches; method developed for measuring stress distribution in plane of contact between rolls and material passing through rolling mill; use is made of piezo-electric effect to measure applied pressures; pressure is maximum in neighborhood of exit from rolls and from their falls on both sides, in axial direction.

Recent Researches on Plasticity—I. G. I. Taylor and H. Quinney. Metallurgist (Supp to Engr) Feb 26 1932 p 25–7. Review of research carried out by authors; maximum stress and maximum strain theories; theory of constant total energy of deformation.

ELASTICITY. Ueber neuere Methoden und Ergebnisse der Elastizitaets - und Schallgeschwindigkeitsmessungen in festen und geschmolzen Metallen, O. Stierstadt. Metallwirtschaft v 11 n 2 and 3 Jan 8 1932 p 18–21 and Jan 15 p 32–4. New methods and results of elasticity and sound-velocity measurements of metals in sold and molten state; relations between mechanical properties of metals in solid and molten state. Bibliography.

FLOW. Observations on Pressure of Fluidity of Annealed Metals, H. O'Neill and H. Greenwood. Inst Metals—Advance Paper n 595 mtg Mar 9–10 1932 21 p. Compression, indentation, and extrusion tests; Brinell hardness and pressure of fluidity; hardening under sinking punch; Bridgman's experiments; fluidity and tensile test; effect of cold work. Bibliography.

TEMPERATURE EFFECT. Festigkeitspruefungen an Stangen und Draehten bei tiefen Temperaturen, F. Pester. Zeit fuer Metallkunde v 24 n 3 Mar 1932 p 67–70. Investigation of tensile properties of rods and wires at low temperatures; results of tests on copper, bronze, aluminum, aldrey, and steel between plus 20 and minus 77 C; in general, low temperatures have no prejudicial influence; tensile strength of all these metals is greater at minus 77 than at plus 20 C; elongation is increased.

MOLDING MACHINES

ELECTRIC. Electromagnetic Moulding Machines for Foundry Works. World Power v 17 n 99 Mar 1932 p 195. Machine is used as direct power medium for molding work; magnetic molder, unlike previous machines designed for similar purpose which embodied pneumatic as well as electrical working, is 100 per cent electric and has no motor attachment.

JARRING. Untersuchungen an einer mit Pressluft betriebenen Ruettelformmaschine von 1000 kg Hubvermoegen, R. Walle. Giesserei v 19 n 9–10 and 13–14 Mar 4 1932 p 81–8 and Apr 1 p 122–7. Investigations of compressed-air jarring machine with lifting capacity of 1000 kg; results of tests and evaluation of diagrams; influence of expansion, air pressure, and load; tests with molding sand as load.

NON-FERROUS METALS

CENTRIFUGAL CASTING. Centrifugal Casting Process as Applied to Non-Ferrous Metals and Alloys, J. E. Hurst. Metal Industry (Lond) v 40 n 3 Jan 15 1932 p 88–92. Application of centrifugal casting to some well-known group of alloys; application to production of castings in brass and bronze; centrifugally cast aluminum bronze and nickel alloys.

OIL ENGINES

AUTOMOTIVE. Fowler Cavity-Piston Oil Engine. Motive Power v 3 n 3 Mar 1932 p 11–12. Design, construction, and operating details of new line of high-speed oil engines; engines available in five sizes, all using 4¾ in. bore and 7 in. stroke; performance curves; lubricating, starting and cooling system.

PHOTOELECTRIC CELLS

APPLICATIONS. New Electronic Tube Applications in Steel Industry, R. F. Yates. Iron Age v 129 n 12 Mar 24 1932 p 724–5. Details of applications in handling sheets from normalizing furnace and in cutting hot rods to predetermined length.

Supplemental Remarks and Demonstrations of Light Sensitive Devices, P. Thomas. Iron and Steel Engr v 9 n 3 Mar 1932 p 128–30 and (discussion) 130–31. Demonstration showing how devices operate; applications shown do not apply to steel mill work, but serve to start imagination off in proper direction. Before Assn Iron and Steel Elec Engrs.

PIPE LINES

BENDS. How to Obtain Flexibility in Pipe Lines, E. T. Cope and E. A. Wert. Power v 75 n 12 Mar 22 1932 p 434–8. Effect of short radii and tangent lengths on flexibility of pipe lines demonstrated; corrugated pipe and creased bends discussed; change of radius of curvature in expansion U-bend; diagrams illustrating various characteristics.

PLANERS

METAL-WORKING. New Giant Planer, H. Hueber. Eng. Progress v 13 n 3 Mar 1932 p 58–9. Machine built by Maschinenfabrik H. A. Waldrich, G.m.b.H., of Siegen, for Dutch customer, total length 85 ft; total width 31 ft; total height 25 ft; total weight 250 tons; weight of table about 70 tons; cutting force about 100,000 lb, corresponding to cross-sectional area of chip of about 0.7 sq in. of cast iron; clear width 14.8 ft; clear height 13.1 ft; planing length 39.4 ft.

PLATES

STRESSES. Stresses Produced in Circular Plate by Eccentric Loading and by Transverse Couple, R. J. Roark. Univ of Wis—Eng Experiment Station—Bul n 74 Jan 1932 41 p. Review of available series of circular plates with free or fixed edges, central or eccentric loads, or central transverse couples; method of testing theory; tests results and comparison with theory; proposed empirical formulas; analysis of drier drum head.

PRESSES

TOGGLE. Humphris Toggle - Action Press. Engineering v 153 n 3455 Apr 1 1932 p 408–9. Press, Invented by F. Humphris, being used in manufacture of nails, washers, etc., by ingenious process, in which perforated sheet so left is available for variety of purposes, such as replacing expanded metal, instead of being treated as scrap; inherent defects of direct crank-operated ram are eliminated.

PUMPS

CENTRIFUGAL. La commande automatique des groupes electro-pompes, G. Sire. Technique Moderne v 24 n 5 Mar 1 1932 p 140–4. Automatic control of rotary electric pumps, i.e., industrial installations with servo-motor control and those using manometric contactor; illustration of various accessary equipment; complete installations; wiring diagrams and characteristic curves.

FEEDWATER. Le problème de l'alimentation des chaudières à haute pression, L. Martin and A. Gubelmann. Science et Industrie v 16 n 217 Feb 1932 p 45–55. Characteristics of high-pressure boilers and preheating of feedwater at temperatures above 100 C have singularly complicated problem of feed pumps; data concerning design of such pumps and precautions to be taken in their installation; results of experiments carried out in France by Cie de Construction Mécanique Procédés Sulzer.

RAIL MOTOR CARS

DIESEL. Swiss Diesel Railcar With Horizontal Engine. Gas and Oil Power v 27 n 318 Mar 1932 p 55–6. Swiss Locomotive and Machine Works, Winterthur, have recently completed railcar of interesting design for service in Switzerland; list of principal dimensions; general design and constructional details; operating features.

DIESEL-ELECTRIC. B. & W.-Engined Railcar in Sweden. Gas and Oil Power v 27 n 318 Mar 1932 p 59. 200 B.H.P. Diesel-electric railcar has completed thorough period of testing of Stockholm-Nynas Railway Co., and is now in regular service; Diesel engine details.

ELECTRIC DRIVE. Electrical Drive for Railcars With Internal-Combustion Engines, S. Miall. Ry Engr v 53 n 626 Mar 1932 p 112–16. Review of systems in use together with their advantages and limitations; selection of suitable driving motor; characteristics of series motor; selection of suitable dynamo; practical results.

GASOLINE. Petrol-Driven Rail Motor Car, Kalka-Simla Railway. Ry Engr v 53 n 626 Mar 1932 p 104–5. Car has been designed on lines of modern luxury road coach practice; design, construction and operating details; diagrams and illustrations showing general arrangement.

PNEUMATIC-TIRED. Pneumatic-Tyred Rail Motor Coach. Engineering v 133 n 3450 Feb 26 1932 p 268. Vehicle brought to England by Michel in Tyre Co., undergoing trial runs on London, Midland and Scottish Railway; resembles large motor coach, except that it is carried on 6-wheeled front truck and 4-wheel rear truck; power unit consists of 27-hp, 4-cyl Panhard sleeve-valve engine; tires are of Michel in pneumatic rail type, measuring 25 in. by 4 in.

REFRIGERANTS

PROPERTIES. Die thermischen Eigenschaften einiger Stoffe von hohem Molekulargewicht, mit besonderer Besuecksichtigung ihrer Verwendung in Kaelte-maschinen mit Turbokompressoren, A. W. Hsia. Beihefte zur Zeit fuer die gesamte Maelte-Industries Series 1 n 2 1931 40 p supp. Thermal properties of substances of high molecular weight; their use in refrigerating machines and turbo-compressors; vapor pressure of methyl bromide in temperature range from minus 75 to plus 190 C and specific weight of fluid and vapor condition determined at different temperatures. Bibliography.

Latent Heat of Some Refrigerants, E. Griffiths and J. H. Awbery. Phys Soc—Proc v 44 pt 2 n